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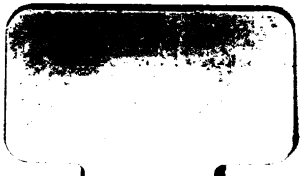

TRANSACTIONS

OF THE

LEEDS

Geological Association.

PART VI.

1890-91.

EDITED BY

W. LOWER CARTER, M.A., F.G.S.

(*Honorary Secretary*).

Leeds:

PRINTED AND PUBLISHED BY RICHARD CROSLAND, 69, WOODHOUSE LANE.

1891.

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NOTE.

The Authors alone are responsible for the facts and opinions contained in their respective Papers.

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REPORT OF THE COUNCIL,

FOR THE SESSION ENDING JUNE 18TH, 1891.

IN presenting their SEVENTEENTH ANNUAL REPORT to the Members of the Leeds Geological Association, the Council have much pleasure in recording that there has been no falling off in the activity or usefulness of the Association during the past session.

MEMBERSHIP.

Twelve new members have been elected during the year, whilst twenty have been removed from the roll, owing either to death, resignation, or removal from the neighbourhood. The Council would note with especial pleasure the addition to our roll, as Honorary Members, of the names of two gentlemen in the front rank of British geologists and palæontologists, Mr. A. Smith Woodward, F.G.S., F.Z.S., of the Natural History Museum, South Kensington, and Mr. J. E. Marr, M.A., F.R.S., Sec. G.S., Fellow of St. John's College, Cambridge. These gentlemen have already rendered the Association excellent service, and have kindly promised their assistance in the future. The roll now numbers 124 members and 10 honorary members.

MEETINGS.

During the past session there have been nine evening meetings of the Association. The papers have maintained the scientific standard of previous years, and the frequent use of the lime-light lantern for illustrative purposes has done much not only to increase interest, but to amplify the educational value of the meetings. By an arrangement with the Leeds Photographic Society, we are able to use the excellent lantern screen which they have erected in the lecture room, and have found it a great advantage. The Council desire to place on record their indebtedness to Mr. J. E. Bedford, F.G.S., for the generous way in which he has placed his lantern at their service. They would also take this opportunity of urging the Members to avail themselves more fully of the advantages which the Association offers for the study of geology, both theoretical and practical.

1. Opening Meeting and Social Evening. Address by the President (Mr. Chas. Brownridge, F.G.S.), on "Our Walls and Pavements."

2. Paper on "Agates," by Mr. C. D. Hardcastle.
   Paper on "A Long-buried Oak," by Mr. B. Holgate, F.G.S.
3. Exhibition of Geological Lantern-slides, in place of a paper by the Rev. E. Jones, F.G.S.
4. Lecture on "The Backbone of England," by Mr. J. E. Marr, M.A., F.R.S., Sec. G.S.
5. Lecture on "A Geological Episode as recorded in the Ingleton Granite," by Mr. Thos. Tate, F.G.S.
6. Paper on "From Kettleness to Saltburn," by Mr. E. Hawkesworth.
7. Paper on "The Geological History of England," by Mr. W. Lower Carter, M.A., F.G.S., with a special series of slides prepared by Mr. A. E. Nichols.
8. Exhibition of Specimens.
9. Lecture on "The Life History of a Volcano," by Mr. W. Lower Carter, M.A., F.G.S., in place of a paper by Mr. S. Chadwick, F.G.S.

EXCURSIONS.

As in previous years the field excursions have been well attended, and have served to throw considerable light on the geological structure of our county. Including those arranged by the Yorkshire Naturalists' Union and the British Association, there have been twelve excursions since the last Report was issued.

1. Ingleton. Silurian. Leader, Mr. C. D. Hardcastle.
2. Kildale in Cleveland. (Y.N.U.) Lias and Oolite. Leaders, Rev. J. Hawell, M.A., and Dr. Veitch.
3. Almes Cliff Crag. Millstone Grit. Leader, Mr. W. Cheetham.
4. Farnley Ironworks. Leaders, Messrs. Hepworth, Stock, and Sheard.
5. Upper Swaledale. Lower Carboniferous. Leader, Mr. J. G. Goodchild, F.G.S., M.B.O.U.
6. Calverley. Millstone Grit. Leader, Mr. W. Cheetham.
7. Ingleborough. (B.A.) Lower Carboniferous. Leaders, Mr. J. E. Bedford, F.G.S., and Rev. E. Maule Cole, M.A., F.G.S.
8. Malham and Gordale. (B.A., and Y.N.U.) Mountain Limestone. Leaders, Mr. R. H. Tiddeman, M.A., F.G.S., and Mr. J. W. Davis, F.L.S., F.G.S., F.S.A.
9. Scarborough. Oolite. Leader, Mr. J. W. Phillips.
10. Leeds Museum. Leader, Prof. L. C. Miall, F.G.S., F.L.S.
11. Leckby Carr. (Y.N.U.) Lower Lias and Glacial. Leader, Mr. T. C. Mitchell, F.S.A.
12. Winterburn Valley Reservoir. Glacial. Leader, Mr. W. Cheetham, and Mr. R. H. Tiddeman, M.A., F.G.S.

TRANSACTIONS.

In accordance with the recommendation of the last Report, the Council have appointed a Publication Committee, consisting of the President, Messrs. Bedford and Hardcastle, and the Hon. Secretary, to arrange for the issue of Part VI. of the Transactions. In order to bring the issue of the Transactions into conformity with the business year of the Association, and thus enable the Report and Balance sheet to be issued to the members shortly after the Annual Meeting, instead of nine months afterwards as heretofore, the Council have decided that Part VI., to be issued in July, shall contain the record of the last eighteen months, and, in future, that the Transactions shall be issued concurrently with each session.

BRITISH ASSOCIATION.

The special feature of the past year has been the visit of the British Association to Leeds. Much was hoped for from the stimulus which it was expected would be given to scientific pursuits by the presence in our town of so many eminent scientists. Though there has been no great accession of activity in our own Association as the result of these meetings, the Council feel that the prominence given to Yorkshire geological work, especially in the Boulder and Photographic departments, ought to encourage the members to a determined endeavour for the attainment of a still higher standard of work in the future. They record with satisfaction that Prof. A. H. Green, F.R.S., F.G.S., one of our Honorary Members, presided over the Geological Section, and that our ex-president, Mr. J. E. Bedford, F.G.S., acted as one of the Secretaries. Papers were read before this Section by two of our members, Mr. B. Holgate, F.G.S., and the Rev. E. Jones, F.G.S. To Mr. Bedford was entrusted the leadership of the British Association Excursion to Ingleborough.

GENERAL.

The work of the Association has gone on smoothly during the year, and the additional officers elected last year have contributed considerably to this result. A Council Meeting has been held each month. In order to lighten the work of the Treasurer and facilitate the collection of subscriptions, the Council have appointed a Collector to undertake that part of the Association's work. Messrs. J. E. Bedford, F.G.S., and C. Brownridge, F.G.S., have been appointed delegates to the International Council of Hygiene and Demography.

LIBRARY.

The Council have much pleasure in acknowledging with many thanks the receipt of the following works for the library, most of which have been sent in exchange for our Transactions :—

Transactions of the United States Geological Survey, 8th Annual Report, parts 1 & 2—1886-7.
Smithsonian Reports—1887—2 vols.
Do. —1888—2 vols.
Transactions of the Geological Society of Australia, Vol. I, Part 5.
Records of the Australian Museum, Vol. I., Nos. 1, 4 & 5.
Report of the Trustees of the Australian Museum, 1889.
List of Members of the Geological Society of Australia, 1890-91.
Proceedings of the Liverpool Geological Society, Parts 2, Vol. VI.
Transactions of the Liverpool Geological Association, Vol. IX.,1888-89.
Do. do. Vol. X., 1889-90.
Transactions of the Edinburgh Geological Society, Vol. VI., Part 2.
Transactions of the Yorkshire Naturalists' Union, Part 13.
Decimal Coinage, Weights and Measures, by Molesworth and Dowson.
On the Geological History of Iron Ores, by W. H. Huddleston, F.R.S., Sec. G.S.
Report of the British Association, Leeds Meeting, 1890.
Annuaire Géologique Universel, Vol. V. Paris, 1889.

PAPERS

READ BEFORE THE

Leeds Geological Association.

JANUARY, 16TH, 1890.

Mr. J. E. BEDFORD, F.G.S., the President, in the Chair.

"FOSSIL FISHES OF THE CHALK."

BY MR. J. W. DAVIS, F.G.S., F.L.S., F.S.A.

(*Abstract.*)

The notes in this paper apply only to those genera and species of Selachians, from the Chalk and Tertiary formations, having the Asterospondylic form of vertebræ of Dr. Carl Hasse, and comprised in the family Lamnidæ, as most recently defined by Mr. A. Smith Woodward, in the catalogue of the fossil fishes in the British Museum. The family comprises the following genera:—Alopecias, Cetorhinus, Corax (Agassiz), Lamna (Cuvier), Odontaspis, Ag., Oxyrhina, Ag., Seaphanorhinchus, A.S.W., Rhinognathus (Davis), Carcharodon, Otodus, Ag.

The four or five species of Sphenodus (known only by their teeth remains) are characterised by teeth having wide bases with slender median crowns. They are found in the Jurassic rocks of the continent, but have not yet been discovered in England. Alopecias is found in the Eocene strata of Prussia; Cetorhinus occurs in Tertiary strata at Antwerp, Italy, &c.; Corax is known only by the teeth which are of world-wide distribution; the teeth have a central cavity; the teeth of existing fishes are hollow. The genus Carcharodon is separated by Smith from the genus Carcharias. The type of the genus is Carcharodon rondeletti, and microscopical examination has distinguished the two genera, Carcharias having hollow teeth, and Carcharodon solid ones. In the single existing species, C. rondeletti, the teeth are 1½in. long, and the entire length of the fish is 40 feet. The teeth of the Tertiary representative of the genus, C. megalodon, are from four to five inches in length, and the fish must have been gigantic in size. C. rondeletti has teeth which are triangular, with serrated edges, and without lateral cones or denticles. Agassiz included in the genus several forms having well-developed lateral denticles on their anterior and posterior

borders ; and although he noted the irregularity in form, he did not consider them of sufficient importance to found a new genus for their reception.

The teeth of Otodus are only known in the fossil state ; they appeared to Agassiz to be intermediate between Carcharodon, Oxyrhina, and Lamna. They resemble the latter in having lateral denticles, but while those of Lamna are cylindrical and sharp-pointed, those of Otodus are larger, flat, and blunt. The microscope shows the teeth to be solid and massive, as in Carcharodon. The genus first appears in the Cretaceous, was abundant in the Tertiary, but died out before the existing period.

The genus Oxyrhina includes one or two existing species, the type of the genus is O. Spallanzani; the teeth are free from lateral denticles, have smooth margins, and attain a considerable size, conforming to the usual arrangement of shark's teeth.

The genus Lamna (Cuvier) included several fishes since taken as types of other genera, as Otodus, Carcharodon, and Oxyrhina ; the character of the teeth being like those of existing sharks, Lamna cornubica may be taken as the type of the genus. Some naturalists have based their classification on external features, such as the position of the fins and the branchial arches, paying little attention to the form of skeleton or dentition. In some cases, as in Lamna and Odontaspis, a separation has been laid down on this account, although the teeth prove them to be very nearly related ; whereas Cetorhinus, Oxyrhina, and Carcharodon, having teeth of great dissimilarity to Lamna, are grouped in the same family. The teeth of Lamna cornubica differ in form according to their position in the jaws ; the crown of the tooth is high and cone-shaped, with smooth margins, and single lateral denticles exist on each side of the cone. It somewhat resembles Otodus and Odontaspis, but the latter is often twisted, and its denticles are longer and more pointed. Lamna has only one denticle on each side, but in Odontaspis there are frequently two and occasionally three on each side. Oxyrhina has no lateral denticles. There is some difficulty in distinguishing between Lamna and Otodus, as some intermediate species appear to bridge over the limits between the two genera. The genus Odontaspis is represented by species still living. Another genus of the Lamnidæ occurs in the Chalk of Mount Lebanon, and was described by the writer (Mr. Davis) as Rhinognathus. It forms one of the very few instances in which the body of a Lamnoid fish with teeth in the natural position has been found in the fossil state. Dr. H. E. Sauvage, in 1872, describes the fish remains in the Cretaceous rocks of Sarthe. He states that in the young stages Lamna has teeth without denticles, and that they only develop later in life. He quotes an observation from M.

Pictet, "that the teeth in many instances vary more from different parts of the same mouth than their homologues in another species, and that this variation renders the difficulty of their interpretation great." This observation applies with considerable force to Lamna and Odontaspis, the teeth of which closely resemble each other, but the fishes still existing enable the naturalist to study and compare them.

The most profitable method of investigating fossil remains is by comparison with existing forms, and it is fortunate that all the genera are not extinct. Though the fossil forms far outnumber the existing ones, there are still examples of Carcharodon, Lamna, Oxyrhina, and Odontaspis. The position of fins and tail in the three former are so similar as not to indicate any generic differences. Odontaspis differs from those named in the form and position of fins and tail to such an extent as to induce Sauvage to place it in a separate family; whilst, judging from the teeth alone, Agassiz and others have regarded it as only a sub-genus of Lamna. Having regard to the remaining genera, Lamna, Otodus, and Odontaspis, existing species of the first and last still remain, but no specimen of a living Otodus has been discovered. Still so many wonderful types of fish have been found by deep-sea dredging and more careful research during the last few years, that it may not be impossible for new genera yet to be discovered. At any rate, until more reliable information is accessible, it may best serve the purpose of the palæontologist to regard the dismembered fragments simply as "forms," exhibiting certain tendencies of a more or less definite character. One of the principal difficulties appears to be that it is desired to make an extremely large series of fossils, representing an enormous development of the Selachians, fit to a minimised series of living representatives, which are rapidly dying out, and that sufficient credit is not given to the variety and number of the species which obtained during the ascendency of the family. Accepting this view, it may be advisable to regard the teeth as forms representing members of the family, and classify them accordingly. It scarcely seems necessary to suggest that the successive redistribution of species amongst existing or newly devised genera is to be deprecated. The genera as defined by Agassiz embrace already a wide range of species, and have hitherto proved adequate. They are universally known and accepted and have tolerably well-defined limits. Taking as types Otodus obliquus, the existing species Lamna cornubica and Odontaspis ferox, the palæontologist will be able to group the ever-varying fossil forms around these centres, and though they may possess characters expressing relationship with more than one species, succeeding discoveries may show that these only express the connecting links

of an unbroken line of evolutional development.

Mr. Ald. Hill, of Morley, and Mr. W. Lower Carter, M.A., F.G.S., proposed and seconded votes of thanks to Mr. Davis for his learned and valuable description of these ancient monsters of the deep, and to Mr. Jefferson for the remarkably clear and vivid manner in which he delivered the paper on behalf of the author. A good discussion also followed. S. A. A.

FEBRUARY 20TH, 1890.

Mr. J. E. BEDFORD, F.G.S., the President, in the Chair.

"A GEOLOGICAL TOUR THROUGH DURHAM INTO CUMBERLAND."

BY MR. WILLIAM CHEETHAM.

(*Abstract.*)

Horsforth, the residence of Mr. Cheetham, was the starting point, and as the City of Durham is rather over eighty miles away, or where you enter the county about sixty miles distant, there was plenty of variety. With a good horse, said Mr. Cheetham, the distance could be covered in a couple of days, but as the whole of the tour extends to a few hundreds of miles, we considered it best to let "Donald" have an easy time at the beginning; so we leisurely crossed Carr Bridge, through Moseley Wood, on to Bramhope, and down Creskeld Lane into Wharfedale, going down the dale to Rawden Hill, where we stayed the first night.

The commanding aspect of Rawden Hill is due to what we may call its geological anatomy. It is an outlier of the Third Grits, standing out prominently and isolated almost into the middle of the valley. The view is certainly one of the finest, if not the most magnificent, in the dale. Almes Cliff is before us, and I may point out a feature in connection with this crag which appears to have not been alluded to. The highest ridge of this fine escarpment faces to the west, and the summit is formed of a rough grit that hardens with exposure. Underneath it the layer of stone is of a softer character, which succumbs readily to atmospheric denudation, and so has furnished the fierce westerly winds with a supply of fine sand to form the sand blast that has carved the underside of the summit into what looks like an ornamental balustrade. Being in no haste to leave this fine neighbourhood, it was nearly noon next day before the old road was taken past Weardley to Harewood Bridge, and so on to Harrogate, and thence in the evening over the Stray and past Starbeck to Knaresborough.

The view from the bridge at Knaresborough forms a most interesting picture. The place is so sheltered, and the waters lie so still, deep down the narrow gorge, that the rocks, trees, old church, houses, and the remains of the castle are clearly duplicated in reverse upon the water. Sometimes you can scarcely discern the shore line, so as to see which is real and which the reflection; but this beauty is not altogether due to nature. Were it not that the stream of the Nidd is dammed up for mill purposes, it would be seen rippling over a rocky bottom, almost without reflecting its fine surroundings. Leaving Knaresborough, the district of the York and Ainsty Hunt is entered upon, and we are fairly upon the Permian formation. There may not at first sight appear much in common betwixt hunting and geology, but the generally level character of the Permians furnishes some of the best hunting grounds in the kingdom, and amongst the first must be classed the York and Ainsty.

The eight miles to Boroughbridge is very pleasant driving, passing Scriven Park, Ferrensby, Staveley, and Minskip, and just outside the town we strike into the great North Road from London to Edinburgh, which is yet one of the finest driving roads in the kingdom. Comfortable quarters for man and horse were found at the Crown, and next morning, crossing the fine bridge, there was a good spell of collar work for Donald a couple of miles up to Kirkby Hill, and then about twenty miles of splendid road, almost as straight as an arrow, to Catterick Bridge, on the Swale. Yet it is by no means a dead level; were the slight covering of soil removed, we should see that we were crossing long sandy hollows with ridges of shingle beds from half a mile to a mile apart, with just one farm-house on the summit of each ridge. In pre-railway days almost all these farm-houses were inns, but now their occupation is gone, and you may go ten miles without one being passed. The road-metal is procured from the gravel-beds all along the route, and in some places rather considerable excavations have been made, which afford good opportunities for the hammer. About fourteen miles from Boroughbridge the long straggling village of Londonderry is passed through, when you come to Leeming Lane, famous for trotting matches. Two miles further the village of Leeming is passed through, and six miles more bring you to Catterick Bridge.

A long, hard pull of about four miles brought us to Scotch Corner, which is a splendid point from which to take a general survey. A whole paper would be required to give an account of the geological formations that surround it; but this strategic part of the military Roman road of Watling Street must have some notice. Some seventeen hundred years ago, when it was

constructed, the local roads connecting the towns east and west of it were the lines of district traffic, as they have remained to the present day. Like the North-Eastern Railway, being a through route, it passed through the country with little or no regard to local requirements. From the fork here the N.W. branch went direct to Scotland, though it would almost appear that the direct route was right forward on the road we were going; but we must remember that Edinburgh, although on the east coast, is farther west than Carlisle. Another branch about fifty miles from here goes right over the shoulder of Cross Fell, a wild and desolate district, and is considered to be the finest constructed Roman road in the kingdom. It is yet known there by its original poetic name of the "Maiden Way." Although through railway routes have taken the life out of these through Roman roads, yet the older local roads do not appear to have been materially affected, and the traffic is carried over them much as it probably was nearly two thousand years ago.

About seven miles further north we entered Durham at Pierce Bridge, on the Tees, a most beautiful spot, deep down in the Magnesian Limestone. On the north side of the river there are the remains of a Roman encampment, and the raised ground about it is yet known as the Roman Ridge. It was getting dusk when we left, and by the time we got to West Auckland, having had to pass over a hilly country, it was quite dark, and a little rain had begun to fall. The object of the journey being to make ourselves acquainted with the thirty miles of Upper Weardale, we were off in good time the next morning, but were doomed to be sadly disappointed.

A little rain was coming down as we started; of course we hoped that it would clear up, especially as the wind appeared to be getting up, but the weather grew worse and worse, and most of the day's journey to Wear Head was passed amid hurricanes of wind and rain, most unpleasant travelling, and making field work impossible. We passed through Wolsingham, Frosterley, Stanhope, St. John's Chapel, and Wear Head, to Burtreeford, and Donald was eventually taken out at the hotel at Cowshill in a regular deluge of rain. Knowing that an account would have to be rendered of my visit, and the weather having effectually prevented on this occasion any research, I paid another visit to this district subsequently, making Stanhope head-quarters, and was fortunate in having magnificent weather.

Stanhope is a picturesque ancient town, with pleasant walks—the trees in the Lime Tree Walk are said to be the finest in the north of England. It has given its name to the family of the Earls of Chesterfield, also to our Horsforth Stanhopes of Cannon Hall. Some celebrated men are connected with this district.

Bishop Butler wrote his "Analogy" during the time he was rector here, about 1736. The American poet and philosopher, Ralph Waldo Emerson, was a descendant of the Emersons of Weardale. Thomas Sopwith, F.R.S., resided between St. John's Chapel and Wear Head. You will remember the artistic geological models made by him which were exhibited before our Association five or six years ago. He also published several accounts of the lead mining districts of Alston, Weardale, and Tindale. Mr. Egglestone is the author of several interesting works on Stanhope and the neighbourhood, and I am indebted to him for his kindness and valuable information, and also for an introduction to Mr. Trawhall, who possesses a fine collection of mineral specimens. We also called upon Mr. Craig, a quarryman, who has got together a quantity of good fossils. I have also to thank Mr. Powell, of Crawleyside, who has a grand collection. I was much interested in a number he had from the sandstone rock on the hill top. They are beautifully marked with what look like impressions of heather, which Mr. Powell seemed to suppose had some connection with them, as it grows on the top of the hill. However, comparison with specimens of the Marsden Rock, near Sunderland (Magnesian Limestone), noted for similar but finer markings, shows them to have been produced by the same action, viz., infiltration. To Mr. Parmley, an official at the immense quarries of Messrs. Ord and Maddison, I am indebted for the large specimens from the "Thick Cockle Post," which furnishes the celebrated Frosterley and Stanhope marbles. Our ordinary geological hammer made no impression on the solid rock, but a twenty-pound hammer swung with accurate aim soon detached what we required.

The Great Limestone dips from the Pennine range to the north-east at the rate of about 60ft. per mile, and is usually about 72ft. in thickness. Some 20,000 tons a week are quarried and sent away (to be used as a flux in smelting the iron ores of Durham and Cleveland) from the various quarries of Stanhope and Frosterley. It is divided into a number of layers (usually denominated "posts"), each having in the quarrymen's geology a distinctive name. Thus on the top are the "Five Posts," then "Toby Giles," next the "Crabby," then the "Mucky Posts," then the prettily spotted layer called "Rosemary" or "Pea Post," next is "Elsy," and then come the "Thin" and "Thick" Cockle Posts, which, with the "Dunket," furnish the Stanhope and Frosterley marbles; next are the "Twee Toms," the "Black Bed," and the "Five Thin Post;" next the "Dunket Post," the "Dunket Bastard," and "Dun Jinn." Below these comes a rock hard to work, known as "Stiff Dick," followed by "Whaley," also a tough customer; and finally the four layers termed the

"Yard," "Jack," "Newcastle," and "Bottom Posts." The font in the church is very massive, with an exquisite polish. The base exhibits a large quantity of fossils, whilst in the upper part they are not numerous; so appear as if they were inlaid as ornaments. Just within the gates of the churchyard are a number of very ancient stone and marble coffins, discovered during the alterations of the church in 1867. One of them appears to be from the "Dunket Post," and exhibits beautiful fossils.

The atmosphere of Upper Weardale is very pure, and the parish registers show that some of the inhabitants have lived to a very great age, one being recorded as dying in her 105th year; but there are also records of many who have perished in snowstorms on the hills. Although the district has of late years been much frequented as a health resort, I should hardly think it a suitable place for nervous invalids. For early in the morning, when in the state that Moore in his Irish melodies describes as "'Twixt sleeping and waking," a cannonading began, which seemed to be close under the bedroom windows. It might not have awakened the sleepers in the adjoining churchyard, but it certainly must have shaken them. Then came thundering answers from the attacking forces in the quarries on Newlandside, over the Wear. There was no more sleep for me with gunpowder and dynamite raging around to enable the rock to be torn from its bed. So, making a virtue of necessity, I rose early, and went down to see the Little Whin Sill at the Briggen Winch before breakfast; it is 20ft. thick at this place. Lebour's "Geological Outlines of Durham" clearly shows it to be an intrusive igneous rock, and as far as regards the Whin Sill itself, it is no longer an open question. The dispute, you will remember, originated in one of the few errors of Professor Phillips, who had relied on this basaltic sheet as a boundary between his divisions of the Yoredale Rocks and the Scaur Limestone. It was interesting to note that the bridge had been duplicated in width, and that the older part had been built ribbed, as at Settle, Otley, and the Brig o'Doon. In Weardale, as in our north-west Yorkshire limestone district, waterfalls, cascades, and caverns abound. In Heather Burn Cave, near the red vein, numerous relics were found; the human remains have been described by Professor Huxley; but this cave, as well as those at Bolihope and Raygill, has disappeared owing to quarrying. Speaking of the red vein reminds me that iron ore is extensively worked, nearly one hundred thousand tons being raised annually. Lead and iron mines have been worked in Western Durham from time immemorial, but their great development only took place after the opening of the Stanhope

and Tyne railway in 1834.

This railway goes no further than Stanhope for general traffic, but a well-horsed 'bus, carrying Her Majesty's mails, goes twice a day beyond Wear Head to Cowshill, and in the tourist season once a week (Wednesday) over the mountains to Alston in Cumberland. At 8.50 on a clear, bright, frosty morning, I took a box-seat, and it was a grand change from the previous journey in the rain, which came to such a speedy and unsatisfactory termination. With three horses and only another passenger, we rattled along in fine style. There was nothing in the general character of the country to show that we were not in one of our North Yorkshire dales. No arable land, but meadows in the bottoms, and stony pastures reaching high up the hillsides, with heather on the summits. Wear Head, like Aire Head and Ribble Head, is not the head of the waters; it is formed by the junction of the Burnhope and Kilhope waters which rise on the moors five or six miles away. Our road takes us by the Kilhope branch; but as we are leaving Weardale proper, we must mention that all the lateral valleys (which with us are termed dales and gills) are called hopes, and the prefix agrees with some peculiar features, as Snowhope, Westernhope, &c.

The end of our journey brought us to Cowshill Hotel, which is very conveniently situated for geological workers, being just above the Burtreeford Dyke, which is said to afford the best geological section in the county of Durham. It runs from the Yorkshire side of the Tees across Weardale to Allenheads, with an upthrow to the west of 500 feet in some places. Here it has burst through the Great Limestone; and just below the Dyke the "Cockle Post" can be observed in the bed of the stream, dipping to the east at an angle of about 18 degrees, whilst west of the Dyke the beds in the stream show nearly level, or have a slight dip to the west. When we resumed our tour the weather looked promising, the clouds having gone up higher, but we soon found out that this was just what we had to do, so in a short time we walked right into them. Indeed, it was a case of walking most of the way to the watershed at Kilhope Cross, where the counties of Durham, Cumberland, and Northumberland meet. There was nothing to be seen but deserted lead mines, the very picture of desolation.

We reached Alston about noon, and at three o'clock started for Teesdale on our return. It was indeed a solitary journey. At Yad Moss, with Mickle Fell in front and Cross Fell to the west, it seemed as if all the world was moorland and mountain; not a sign of cultivation for mile after mile, only lines of posts to show travellers where the road was when all was buried in snow. We found most superior quarters at Mrs. Barker's,

Langdon Beck Hotel, about two miles above High Force. The journey next day was by High Force and Middleton to Barnard Castle. From there we did some more mountaineering, crossing the Tees and going almost direct south, past the head of Brignall Banks, right over the moors of Arkengarth Forest, down Arkengarthdale to Reeth-in-Swaledale, and again over the moors to Redmire in Wensleydale. Our road thence led by Aysgarth, Buckden, Kettlewell, and Grassington to Burnsall for one day's journey. The last day by Bolton Abbey, Addingham, Ilkley, took us home to Horsforth again, both Donald and myself being benefited by nearly a fortnight spent in the open-air amid grand scenery.

Mr. Cheetham's paper was well illustrated by diagrams, views, and specimens, and at the close he received a hearty vote of thanks for the graphic and interesting description of his tour.

MARCH 20th, 1890.

Mr. J. E. Bedford, F.G.S., the President, in the Chair.

"A GOLD MINE, A SLATE MINE, AND A SALT MINE."

By Professor ARNOLD LUPTON, M.I.C.E., F.G.S.

(*Abstract.*)

Before proceeding with the ordinary business, opportunity was taken by many members to express the great loss the Association had sustained in the decease of Mr. Adamson, and the following resolution was unanimously adopted by the meeting:—"We wish to record our high appreciation of the very valuable services rendered to this society by our late hon. secretary, Mr. S. A. Adamson, F.G.S., and to express our great sorrow that we should lose one who, by his great ability and personal efforts, has been the chief means of raising this society to its present prominent position, and who by his geniality, kindness, and ever ready aid has made himself highly esteemed by all who knew him."

Professor Lupton then read his paper, which was illustrated by a series of beautiful photographs prepared for the lantern. Mining for coal, though so important at the present time, is of recent introduction as compared with mining for metals, as coal-mining was not attempted until wood had become too scarce to use for smelting iron and other metals. Metal mining is very ancient, and is mentioned in the oldest of books. Most metals are found in this country, the notable exceptions are quicksilver and platinum. Petroleum has not been found, nor have diamonds. Gold,

however, was worked in Wales in very ancient times, but was given up long ago because it could be obtained cheaper in some foreign countries, amongst others, say in Africa, where it was washed from the river sand, but its presence in the river sand only showed that it had been washed there from the rocks in the higher parts of the river, and by following the gold to its parent rock gold mining was commenced. It is generally mined in the quartz reefs of Australia, Siberia, the Rocky Mountains, Central America, and India. It is also found in a volcanic crater in Queensland, and the Transvaal conglomerates produce a large quantity. Where the gold occurs in soft material in river beds, or mountain sides, it is freed from its sand and clay by means of water and mercury. If the sand containing the gold be run with a plentiful supply of water along a wooden trough, or spout with wooden ridges nailed on it short distances apart, the gold by its great weight sinks to the bottom, whilst the sand and clay are washed away by the water; but if at the bottom of this trough we have something which will readily combine with the gold, leaving the other substances to pass away, a great difficulty will be solved. Now this is done by placing copper plates covered with quicksilver at the bottom of these troughs. The quicksilver has a strong affinity for the gold, and amalgamates with it at once. The amalgam is then heated and the quicksilver evaporates, being condensed in another vessel, ready for use in the same manner again. When soft material on a hill-side is worked it is done by means of a fire hose. The whole material is washed down, and the same process is gone through as named above.

Gold is often found in veins of quartz, which is one of the hardest of rocks. This quartz is blasted out in lumps, which are subjected to the action of the stamping mill. As the stamp comes down crushing the quartz it is plentifully supplied with water, and at one side of the stamp is a wire gauze, only a little wider in the mesh than that used for miners' safety lamps. The quartz and any particles of gold it may contain being thus reduced to a very fine powder are passed along a trough, and the gold is separated as described above.

In Australia mines will pay if they can manage to get five pennyweights of gold out of a ton of quartz, the value of this gold being 16s. 8d. Speaking of the discovery of gold in Wales, the lecturer pointed out that in this country, seeing that it is in such a settled state, people might invest money with the probability of recouping themselves even after years of trial; with its cheap, ingenious, and good machinery and great skill of its miners—a small quantity of gold per ton would be found to pay; although in other countries great use was made in gold mining of Chinese, Coolie, and Kaffir labour.

Speaking of slate mines, the lecturer took as an example the same rocks as those containing the gold quartz, but in this case it was the rock itself.

Any one who has been to Port Madoc, where the slates are shipped, may have taken a ride by the miniature railway which goes winding and gradually rising amongst the Welsh hills, at one time passing along the brink of a precipice, at another skirting a deep gorge, but almost all the time giving delightful views of the hills and valleys of Wales, arriving ultimately at Festiniog, and here it is we will look into the slate mines. The slate lies at an angle of twenty-three degrees from a horizontal depth under the mountain, but such has been the effect of compression upon this slate that it splits and cleaves at quite a different angle. It is 46 yards thick, and is obtained in large blocks. As soon as the blocks are got to the surface they are split by means of chisels into lesser pieces, and the ends of the blocks are sawn; they are then split up into pieces thin enough for roofing, and the size and shape of the slates is given to them by machinery. The cutting knives are arranged something like those of a hay cutter. Only about 7 per cent. of the weight quarried is turned into roofing slates.

One of the sights in Wales is the Penrhyn Quarry, near Bangor. This quarry has been worked since the time of Queen Elizabeth. It is taking away the entire mountain. Standing on one side of it, we have a vast amphitheatre lying before us. All round are steps, but they are 60ft. in height, and the amphitheatre is nearly one mile across, and of great depth. The men, as they are working the blocks of slate out of the steps, look like specks in the distance, and we are lost in wonder at the magnificent scene before us.

Not very far distant from these quarries are the salt mines of Cheshire at Northwich and Droitwich. The houses at these places are leaning in all directions, and in order to prevent collapse they are built of wood framing with bricks built in between. As, however, the livings of the people depend on the salt industry, which is the cause of all this derangement, they naturally look upon it with more complaisance than they otherwise would do.

Formerly rock salt was mined for in a somewhat similar way to that in which coal is obtained, that is by digging out lumps of rock salt and leaving pillars to support the roof. As, however, one of these mines became flooded with water, and the water was being pumped out it was found that the water had dissolved the pillars in the mine, and that the water came to the surface in the form of brine. Advantage was taken of this, the water was pumped into reservoirs and evaporated off, leaving the fine

crystalline salt in the reservoir. Salt has of late been found also in great quantities at Middlesbrough. They have not taken the trouble to mine for it, but have made a bore hole and pumped the brine to the surface, evaporating the water off in pans. At the close of the lecture a hearty vote of thanks was accorded to the Professor for his instructive and entertaining paper, and to Mr. J. E. Bedford, F.G.S., for his management of the lantern.

B. H.

APRIL 17TH, 1890.

Mr. J. E. BEDFORD, F.G.S., the President, in the Chair.

"THE PHYSICAL PROPERTIES OF ICE AND GLACIERS."

BY DR. J. LEWKOWITSCH, F.C.S., F.I.C.

(Abstract).

All who have travelled in the Yorkshire dales will have noticed mounds standing up here and there, sometimes in the middle of the broad valley, at others against the hill-side in hummocks. Sometimes these mounds are dug into for gravel, and are thus made into gravel quarries; at others, when the sod is taken off, they are found to consist of soft, sticky clay, in which are embedded large and small partially rounded or rough stones, these stones being in many cases scratched and scored. The higher up the dales we go the more of these we find. Sometimes in the upper parts as we pass up we may see perched on the top of escarpments huge pieces of rock of a different kind altogether from those upon which they rest. Up to a comparatively recent time these mounds and strange blocks exercised the ingenuity of the traveller to account for them. Generally speaking they were attributed by the residents to the Flood, and it was with wonder and awe that the stranger gazed upon them and surmised what a vast power must have been brought into operation to place them where they are now found. It is only in comparatively recent years that a solution has been arrived at, and even now there are many problems which remain unexplained, and the Boulder Committees of the British Association and the Yorkshire Naturalists' Union have been organised for the express purpose of clearing them up. We now know that our Yorkshire dales were at one time in a condition similar to some of those in Norway and in the Alps at the present day, and were nearly filled with glaciers, the offspring of perennial snow; and that these glaciers, as they slowly wended their way down the dales, though they did not alter the form of the

surface of the country to any great extent, yet stripped it of its old soil and vegetation—grinding along the sides of the valleys, tearing away in their passage pieces of rock, which they bore on their surface and deposited where we now find them. Other pieces were deposited in such positions as allowed the river waters to wash them down and re-deposit them in a way of its own.

It was, therefore, with pleasure that the Leeds Geological Association listened to a lecture on Glaciers by Dr. Lewkowitsch. Dr. Lewkowitsch has not only done a good deal of Alpine climbing, but has made a study of the physical conditions under which ice acts. He illustrated his lecture by means of lime-light views of the different Alpine glaciers; and by means of a screw press he showed the changes which ice undergoes in structure and behaviour when subjected to pressure. He said that in considering the cause, structure, and movement of glaciers, formed as they are of ice and snow with a good deal of water within and without them, which water is frequently frozen and as often melted, we have to deal with a somewhat complicated subject, a subject which for the last hundred years has taken up the attention of men of science. People not infrequently ask how it is that snow remains on the tops of mountains, and why it is colder there than in the valleys and plains below, seeing that it is nearer the sun. This leads to the first part of the question before us. We all know that we feel warmer, and that the surface of the ground is warmer when the sun shines. This would not be so if the air above us did not allow the sun's rays to pass through without absorbing the heat, thus leaving it to strike the earth and the objects upon it, into which a great part is absorbed, whilst part is reflected back and thrown in all directions into the air and the moisture which it always contains. From this it is evident that the nearer we are to the great mass of earth, in the valleys and plains, the more heat we receive, not only by the direct rays, but by reflection—the high mountain tops receiving but little more than direct rays. But there is another reason. The weight of the great mass of air above us (some 45 miles in height) presses down with greater force on the lower than on the upper regions, owing to the extra height of air upon it, and thus represents so much more work done upon the former than upon the latter. This may be illustrated by performing work on a nail by striking it with a hammer, by which we shall make it red hot. When the air rises, as it does in a wind, it becomes more rarified, and, losing heat in the process, becomes cooler. A similar operation of compressing air, and, after cooling it to the ordinary temperature, allowing it to expand into a chamber full of carcases, is the method used for freezing meat as it is

brought over on board ship. Bearing these facts in mind, we can account for snow lying on the tops of high mountains, for though their peaks may be above the great body of clouds which pour rain upon the valleys, yet there is a large amount of moisture which condenses into snow, and piles higher and higher upon the flanks of the mountains. When these masses have increased so much in weight as to overcome the power which binds them together they slide bodily down the steep mountain side as avalanches, and sometimes they destroy whole forests and villages. But the sun shining upon the snow melts a portion of it, and another portion is melted by the warmth of the earth upon which it rests, and this water running over snow makes large masses of snowy ice, which move slowly down the valleys, and are called glaciers. One of these, the Mer-de-glace, on the side of Mont Blanc, is known by name to most English people. This glacier ice behaves differently from river ice, for whilst the latter is very brittle and cracks under pressure, the former will bend and flatten or draw out. These glaciers move downwards, now widening into open valleys, again squeezing their way through narrow gorges, and then uniting with others which are coming down other valleys. They pass over the hard precipitous rocks in the form of cascades like waterfalls, the ice bendingand breaking and uniting at the bottom. They form cavities called crevasses. They move quickest in the centre and the top, as streams of water do, the bottom and sides being held back by friction. Their movement was first recorded about one hundred years ago by the French naturalist, Saussure, who also was the first successfully to ascend Mont Blanc. This movement was exemplified in a dreadful way. One of his guides was lost in a crevasse, and was found many years after at the melting foot of the glacier, some miles from where he was lost. The properties of heat were not so well known in his day, and he attributed the movement to gravitation alone. Our Professor Forbes made very careful observations with surveying instruments, and found the advance to be at the rate of twenty inches per day in some parts, and thirty-five in others, in the summer time. The stones, sand, and mud are deposited in mounds at the foot of the glacier as it melts, in precisely the same manner as we find them sometimes in our own dales.

A letter of condolence was received from the Hull Geological Society, sympathising with our Association in the loss of our late secretary, Mr. S. A. Adamson, F.G.S. They felt his loss very much, as they owed the formation of their society in a great measure to his instrumentality. On the motion of Mr. C. D. Hardcastle, seconded by Mr. J. Hill, the communication was placed upon the minutes.

B. H.

MAY 15TH, 1890.

Mr. J. E. BEDFORD, F.G.S., the President, in the Chair.

"THE COMMON FOSSIL PLANTS OF THE COAL MEASURES."

BY Mr. JAMES SPENCER.

(*Abstract.*)

During the last few years the strata in which seams of coal lie at distances apart, sometimes of many yards, and which are known as the Coal Measures, have been so minutely studied, and so much lectured about, that there are few who do not at the present time know that what are now coals were at one time forests of trees with a dense undergrowth of ferns and other plants, that grew on the spot where we now find their fossil remains as fuel. Mr. James Spencer, of Halifax, who has for many years made a special study of these plants, and has worked hard at cutting them into slices for examination, was able to bring before the Association the results of a good deal of his work, and the latest and best considered views on the subject, particularly of those in which the forms of tissue have been preserved. His special object was to show the alterations which had taken place in the naming of these plants, and to indicate how they have been re-classified.

Long before Geology was known, scientific men collected fossils as curiosities. In 1784 Professor Suckow discovered a ribbed reed-like fossil, such as we may see almost any day in one of the quarries of our own neighbourhood. This fossil is in outside appearance something like a plant which grows along the edges of our small lakes or ponds, and which we know as the "horse-tail." Professor Suckow named it "Calamite," and it still retains this name. It is the most common of the fossils of the Coal Measures. The greatest progress was made in the study of these remains, however, between 1820 and 1840, when the great botanists, Lindley and Hutton, in this country, and Sternberg and Brogniart, on the continent, were at work on them. Numerous other gentlemen, far removed from each other, soon began to actively study them, and the same fossils were discovered over and over again in different countries and places by different people, who not knowing what others were doing, gave various names to what turned out afterwards to be the same plant. Again, owing to the absence of all knowledge of their structure, a cast of the outside had a different name given to it from the cast of the inside or hollow stem. In this way one plant has had no less than forty-four names, another thirty-seven. This multiplicity of names having been made, it is evident that

upon acquiring more accurate knowledge, much time has had to be spent in the re-arrangement and correction of names, and so it will be readily seen that although we have during recent years discovered many new species of plants, the names are not now so numerous as they were some years ago.

The fossils first found were only casts, as are those generally found now, that is, they are impressions only of the plant, and do not show the tissues and mode of growth, but there are other fossils found in which the form of every cell and particle of tissue is preserved, and it is from these, rather than from the casts, that we are able to trace the life history of the plants and their way of growth and reproduction. Just as we are able by examination of shavings to tell the kind of wood to which it belonged, so are we able by making slices of these fossils sufficiently thin to be transparent, to tell to what order of plants they also belonged.

The Calamite, which was the first fossil noted, is even now a subject of dispute. Professor Williamson, of Owen's College, the greatest living authority on the structure of fossil plants, is of opinion that the casts are only inside moulds of the hollow stemmed plants; whilst Mr. Kidston, of Stirling, who has just published the latest and best book on these plants as judged by their casts and prints of leaves, is of opinion that some are casts of the outside of the plants. When sectionised, they are found to have a hollow stem and to be built up in a circle of twenty or more woody wedges with their points inwards, called the vascular zone. At the point of each is a small hollow tube or duct, the tree having a bark on the outside. The stem is divided into lengths like a horse-tail, a curtain of tissue across the central part, and serving as a binder and strengthener of the stem at each of these joints or nodes. The common kind is called *Calamites Suckowii*, after the original discoverer.

There is another plant of the Coal Measures, the cast of which cannot generally be distinguished from the Calamite. The lecturer, in all his many years of observation, had only seen one which he could clearly so distinguish, and yet its structure is very different from that plant, and when sectionised its stem is found to be not hollow, but to contain a pith of cellular tissue; it has only thirteen wedges of vascular bundles of wood as against twenty in the Calamite, and it is much more common in our coal balls. This plant is known as Astromyelon, from the star-like appearance of its section.

Another common fossil is one having the stem covered with markings somewhat diamond-shaped, the grooves between the markings taking a spiral course about the stem; this fossil is known as a Lepidodendron; the markings are leaf-scars, the

leaves having sprung from them, and being some three inches long and very slender—only about a quarter of an inch broad—the scars being wider than the leaves. Upon a more minute examination it is found that this way of classification does not absolutely hold good, as some plants having a sigillarian structure are also marked in a spiral and a somewhat similar manner to the Lepidodendron. The characteristic of this plant is that it has three dots or marks horizontally across the face of each leaf-scar, the centre dot representing a duct which connected the leaf with the interior of the bark. It has been considered that the two others which do not connect with the inside of the tree, but only into the bark, have served as passages through which the natural gum has oozed (for they are considered to have been gum-bearing trees), trickled down the sides amongst the other vegetation, and has formed part of the coal-making material.

Here is a specimen of the way in which they have been named:—The young plant has not precisely the same appearance as the old one, and is known to some as *Lepidodendron elegans*, and to others as *L. gracilis*; the same plant, when found in a more aged state, is known as *L. obovatum*. Another kind is known to some as *L. sternbergia*, and to others as *L. selaginoides*; another species is known as *L. aculeatum*, and this kind alone has twenty-seven different names. *L. Harcourtii* is not a separate species at all. It is a Lepidodendron without the bark. The structure of the Lepidodendron is a central pith and a woody zone surrounded by a very thick bark upon which grew numerous leaves, something after the manner of those on the Araucaria.

Another common plant of the Coal Measures is the Sigillaria. This name was originally given to the series having seal-like leaf-scars running vertically along the stem, and not spirally, as in the Lepidodendron. As before stated, some species of this plant have their markings lattice-like and placed diagonally. Its glandular ducts are kidney-shaped or reniform. Although the casts of this plant are so very common, its stem with structure is very rare. We find it generally flattened and with its bark, but with the central pith entirely gone. Mr. Spencer has only found three specimens with the central pith present, and these were most difficult to obtain, they were so fragile. *Sig. organum* is not now acknowledged as a species, it is only a Sigillaria under different conditions. Mr. Kidston considers that some of these plants had fruit cones something like those of the pine, and that they grew at right angles from opposite sides of fruit-bearing stems, and so closely as to leave an impression in the bark where they had grown. Until this was discovered the stems were considered to be separate plants, and were named Ullodendron. The ferns of the Coal Measures did not differ materially from those

of the present day, and have been named from the way in which the leaves are marked, and so we have the Neuropteris, Pecopteris, Sphenopteris, &c.

The lecture was illustrated by means of numerous diagrams, showing the patterns of the various leaf-scars; also by enlarged views of cross-sections of the several plants alluded to.

Messrs. Jefferson, Nettleton, and Carter, took part in the discussion which followed, and a hearty vote of thanks to the lecturer was moved by Mr. Cheetham, and seconded by Mr. Hardcastle. B. H.

MAY 29th, 1890.

Mr. J. E. BEDFORD, F.G.S., the President, in the Chair.

EXHIBITION OF SPECIMENS.

The lecture given by Mr. Spencer on the "Fossil Plants of the Coal Measures" having served again to raise the interest of the members in this subject, Mr. W. H. Gill, who has spent much time in collecting fossils of this kind, made a very good show on this occasion. They were of great variety, and the different types were well and clearly represented. Amongst others were different kinds of Calamites, the nodes in some being much closer in proportion to their diameter than in others. Some showed, by their tapering form and rounded ends, that they were clearly internal casts of stems, and others, which were long and straight, might probably have been outside casts. The Lepidodendron was represented by fine specimens of selaginoides, also named obovatum, &c., &c., the names differing as the age of the plant and forms of the leaf-scars varied. He also showed a very good cast of the thorn-like fossil known as "Halonia." This was at one time considered to be the stem of a creeping plant allied to the club mosses of the present day, the knobs representing the places whence the roots had proceeded; now they are regarded as the cone-producing spikes of the Lepidophloios, a near relative of the Lepidodendron. He also had a fossil known as Sternbergia, which is the central pith of the Dadoxylon, the ancient representative of the pine tribe, together with its supposed fruit, a three-ribbed nut about the size of the common hazel nut, and known as the Trigonocarpon.

Fresh water shells, known as Anthracosia, from above the Beeston bed of coal, were shown, as also a Goniatite from above the Halifax bed. This shell is almost similar in form to that of the "Portuguese man-of-war" met with at the present day in the broad ocean.

Mr. C. D. Hardcastle showed part of his large collection of

minerals, those exhibited on this occasion representing two sets, one containing different proportions of carbon, and the other of alumina.

We are all so accustomed to look upon everything containing carbon as of a black colour, that we are apt to forget that the diamond—the hardest mineral known—is pure carbon in a crystallized form. This valuable brilliant is found in pockets of a material which is thought to be volcanic ash. The carbonado, or black diamond, is also found in similar situations, but it is in the amorphous and not in the crystallized state. The other known carbon compounds are nearly all black. Graphite, or black lead—which is not lead at all—contains 94 to 96 per cent. Anthracite, the shining but flameless coal found in South Wales, and largely in the United States, contains 90 to 96 per cent.; elaterite, or elastic bitumen, from Derbyshire, 85 to 86 per cent.; ordinary bituminous coal 83 to 84 per cent.; cannel coal 80 to 85 per cent.; amber—a fossil gum—79 per cent.; and the proportion becomes less in compact bitumen, brown coal, lignite, jet, mineral charcoal, coke, vegetable charcoal, and fossil wood. Fine specimens of all these were exhibited.

The minerals containing a high per-centage of alumina made a fine display of brilliant and precious stones, and consisted of sapphire, ruby, Oriental topaz, chrysoberyl, bauxite, torquoise, tourmaline, websterite, epidote, felspar, labradorite, lapis-lazuli, garnet, cryolite, as well as the different kinds of clays and the metal aluminium. Mr. Hardcastle described the way in which aluminium, the lightest of metals, and one which will very probably soon be comparatively cheap, is extracted from its ore, common clay, but it is now principally extracted from bauxite and cryolite, for they contain other substances which assist in the reduction. The exhibition was a splendid one, and contained numerous precious gems.

JUNE 19th, 1890.

Mr. J. E. Bedford, F.G.S., the President, in the Chair.

ANNUAL MEETING.

The President in opening the proceedings gave the members an account of the steps which had been taken by the Council for the conduct of the affairs of the Association since the death of Mr. Adamson. He also referred to the excellence of the work done by the Association during the year, and expressed an earnest hope that the members would do their utmost to maintain the usefulness and high position of the Association during the next Session.

The Secretary *pro tem*, (Mr. W. L. Carter, M.A., F.G.S.) then read the Report of the Council for the Session 1889-90.

The adoption of the Report was moved by Mr. Wm. Cheetham, seconded by Mr. T. W. Bell, and carried unanimously.

The Treasurer (Mr. W. H. Gill), presented the Financial Statement and Balance Sheet, which was very satisfactory, showing a balance on the right side.

The adoption of the Treasurer's Report was moved by Mr. Nunns, seconded by Mr. Jas. Hill, and carried unanimously.

A hearty vote of thanks to the Writers of Papers and the Leaders of Excursions was moved by Mr. E. Hawkesworth, seconded by Mr. J. Ingleby, and carried unanimously.

The following resolution was proposed by Mr. W. Cheetham, seconded by Mr. Nunns, and carried with unanimity:—"That the best thanks of the Association be given to Messrs. B. and C. Holgate, for their kind and able assistance in the secretarial duties during the interval since Mr. Adamson's death."

The Officers for the Session 1890-1 were then elected.

President— Mr. CHAS. BROWNRIDGE, F.G.S., A.M.I.C.E.
Proposed by Mr. J. E. Bedford,
Seconded by Mr. T. W. Bell.

Vice-Presidents—Mr. T. W. BELL,
Mr. WM. CHEETHAM,
Mr. C. D. HARDCASTLE,
Mr. B. HOLGATE, F.G.S., and
Mr. J. E. BEDFORD, F.G.S.
Proposed by Mr. W. H. Gill,
Seconded by Mr. W. L. Carter.

Hon. Treasurer—Mr. W. H. GILL.
Proposed by Mr. Nettleton,
Seconded by Mr. B. Pheasey.

Hon. Secretary—Mr. W. LOWER CARTER. M.A., F.G.S.
Proposed by Mr. T. W. Bell,
Seconded by Mr. C. D. Hardcastle.

Hon. Assistant Secretaries—
Mr. A. E. NICHOLS, and
Mr. EDWIN HAWKESWORTH.
Proposed by Mr. H. Nettleton,
Seconded by Mr. Jas. Hill.

Members of Council—

Mr. JOHN INGLEBY,
Proposed by Mr. E. Hawkesworth,
Seconded by Mr. C. D. Hardcastle.

Mr. S. JEFFERSON, F.C.S.,
Proposed by Mr. W. Cheetham,
Seconded by Mr. E. Hawkesworth.

Hon. Librarian—Mr. C. BROWNRIDGE, F.G.S.
Proposed by Mr. W. Cheetham,
Seconded by Mr. C. D. Hardcastle.

The proceedings terminated with a hearty vote of thanks to the retiring President (Mr. J. E. Bedford, F.G.S.), for his two years' faithful and valuable services, which was moved by Mr. T. W. Bell, seconded by Mr. C. D. Hardcastle, supported by Messrs. Nunns and Carter, and carried unanimously.

REPORT OF THE COUNCIL

FOR THE SESSION 1889-90.

THE COUNCIL have much satisfaction in presenting the SIXTEENTH ANNUAL REPORT. The last year has been one of considerable prosperity, and the interests of the Association have been actively promoted, and considerable knowledge of geology has been gained, by means of the meetings and excursions.

MEMBERSHIP.

The membership has been well maintained, and after some revision of the roll there remain 130 members and eight honorary members, being the same number as last year.

MEETINGS.

During the Session there have been ten evening meetings of the Association, the attendance at which has been very encouraging.

1. Opening Meeting and Social Evening. Address by the President, Mr. J. E. Bedford, F.G.S., on "The Geology of Grange and District." Exhibition of Specimens and Lantern Slides.
2. Paper on "Atmospheric Circulation," by Mr. W. Lower Carter, M.A., F.G.S.
3. Paper on "A Remnant of Pre-glacial England," by Mr. A. Farrar, jun., F.G.S.

4. Paper on "Minerals as Gems and Precious Stones," by Mr. S. Jefferson, F.C.S.
5. Paper on "Fossil Fishes of the Chalk," by Mr. J. W. Davis, F.G.S., F.L.S., F.S.A.
6. Paper on "Notes on a Tour through Durham into Cumberland," by Mr. Wm. Cheetham.
7. Paper on "A Gold Mine, a Slate Mine, and a Salt Mine," by Professor Arnold Lupton, M.I.C.E., F.G.S.
8. Paper on "Glaciers," by Mr. J. Lewkowitsch, Ph.D., F.C.S., F.I.C.
9. Paper on "Common Fossils of the Coal Measures," by Mr. James Spencer.
10. Exhibition of Specimens.

EXCURSIONS.

The field excursions have maintained their high scientific character, and the interest of the members in them has been unabated, and is a sufficient testimony to their value. Including the excursions organised by the Yorkshire Naturalists' Union, there have been in all eight field excursions taken since the last annual meeting.

1. Hebden Bridge and Crimsworth Dean. Millstone Grit and Yoredale. Leader, Mr. Jas. Spencer.
2. Nidd Bridge to Harrogate. (Y.N.U.). Permian to Yoredale. Leader, Mr. S. A. Adamson, F.G.S.
3. Upper Teesdale. (Y.N.U.) Carboniferous and Whin Sill. Leader, Major Bainbridge.
4. Eccleshill. Coal Measures. Leader, Mr. Wm. Cheetham.
5. Castleford. Lower Coal Measures. Leader, Mr. B. Holgate, F.G.S.
6. Laisterdyke. Glacial Deposits. Leader, Mr. Thos. Tate, F.G.S.
7. Lowthorpe. (Y.N.U.) Upper Chalk.
8. Bretton Park. (Y.N.U.) Middle Coal Measures.

OUR ROOMS.

The anticipations of the COUNCIL with regard to the new rooms for our meetings have been fully realized. Not only has the comfort of the members been considerably increased, but the use of a good blackboard, and abundant space for the exhibition of diagrams have added greatly to the interest and instruction gained from the lectures and papers.

THE SECRETARIAT.

By the untimely death of Mr. S. A. ADAMSON, F.G.S., the Association has lost an energetic and painstaking Secretary, and one whose place it will be hard to fill. On behalf of the Association the

COUNCIL sent a letter of condolence to Mrs. ADAMSON, and they and a number of the members attended his funeral.

The COUNCIL would take this opportunity of reminding the members of the Testimonial Fund which is being raised, and which gives us an opportunity of showing appreciation of the worth and work of our late Secretary in a practical way.

During the months which have elapsed since the death of Mr. ADAMSON the COUNCIL have done their utmost to make up for his loss, and they gratefully acknowledge the kind and hearty help of Mr. B. HOLGATE, F.G.S., as Secretary *pro tem.*, with the assistance of Mr. A. E. NICHOLS and Mr. CHAS. HOLGATE.

NEW OFFICERS.

The COUNCIL have appointed four of their members, viz., the PRESIDENT, Messrs. GILL, HOLGATE, and CARTER, to form a Publication Committee for the issuing of Part V. of the Transactions. They recommend the appointment of such a committee year by year, consisting of the President, the Honorary Secretary, and two other members of the COUNCIL.

The growth of our Association has resulted in a large increase of the secretarial work, and the COUNCIL recommend the appointment of two Honorary Assistant Secretaries, who shall, *ex officio*, have seats on the Council.

GENERAL.

The COUNCIL tender their sincere and hearty thanks to those gentlemen who during the past session have read papers before the Association or conducted field excursions.

It is hoped that Part V. of the Transactions, the publication of which has been unavoidably delayed, will be in the hands of the members in the course of a few weeks.

The COUNCIL anticipate that the forthcoming visit of the British Association to Leeds will do much to stimulate interest in Geology, and, as a consequence, they confidently look for the increased prosperity of our Association.

SESSION 1890-91.

SOCIAL EVENING—OCT. 16th, 1890.

The Opening Meeting of the New Session was held in the Mechanics' Institution, and took the form of a Social Meeting of the members and friends of the Association. Tea and coffee were provided at 7-30, and an hour of pleasant intercourse was enjoyed.

Collections of specimens were exhibited by Messrs. Hardcastle, Brownridge, Hawkesworth, and Carter, and Messrs. Tate and Brownridge showed some interesting microscopical slides. At 8-30 the PRESIDENT (Mr. C. Brownridge, F.G.S.) delivered his inaugural address, entitled:

OUR WALLS AND PAVEMENTS.

The season's dial has once again swung round and the time arrived when we change the open air class-room with nature's own illustrative diagrams for that of the lecture-room and the aid of art, and by your will it is my duty to-night to formally open the winter session of 1890-91. The Association may be congratulated on its steady continued success since you were last addressed at an inaugural meeting, and that through a time of great trial and serious loss. The Great Hand has been seriously felt in our midst, and we have to mourn the loss of men whose memory will ever remain with us. Samuel Arthur Adamson, F.G.S., our late secretary, was one whose personal friendship and ready help so many of us enjoyed. His work in this Association chiefly made for it the name and position it at present holds outside our local circle. Frederic Green took a deep interest in the progress and work of the society. Benjamin Pheasey was conspicuous at all our meetings and excursions, and took a great interest in all its work. These losses by death impose upon us a high duty—so to carry on the work they have helped to build up and establish, that it may be a fitting monument to their memory. The future work of the society is deserving of a few words. Our work should always be of a progressive character—each year being better than its predecessor. It would be a great attraction and be especially instructive if an Easter holiday excursion could be arranged to go over some well-marked physical district, such as the Lake District of North Wales, and as this has been in many of our minds for a long time, it would be interesting to

make the experiment during the ensuing year. Then it will be well to consider if we could not have inter-monthly meetings, specially for our members to give us a description of the districts visited during their holidays—not for a set scientific paper, but more in the way of notes and illustrations, giving an opportunity, whilst fresh in the memory, of describing any point of interest or the specimens obtained. The amateur geologist requires in the earlier days of study something interspersed with the more abstract portion of the science, to make it attractive and draw him to take a greater interest in the subjects that may of themselves at first seem difficult and dry. This is now being done in a very great measure by the introduction and use of powerful auxiliaries, such as photography and microscopy, and the help of these in popularising and extending scientific work, is deserving of great praise and recognition. In the former branch we in our society have ample valuable assistance from gentlemen who rank among the best amateurs in our town. If we could get a good adept with the microscope to give a practical demonstration on its application to petrological work it would open out, so far as this society's work is concerned, that useful branch of geology which is rapidly becoming of the first importance, and so augment the range and variety of our work. The geological photograph survey of our county and the labours of the Boulder Committee can be greatly assisted, and the high reputation of our society for its work in these branches maintained, if individual members, when out on excursions, and seeing good sections or coming across erratics, would obtain photographs of the same or report them to the secretary, and in this way extend the work to parts untouched by the organised excursions. It was a great source of pleasure, during the recent meeting of the British Association in Leeds, to hear Yorkshire quoted by eminent scientists, and held up as a pattern for example in these works. Dr. Crosskey, the secretary to the British Association Boulder Committee, especially eulogised the work of the late Mr. Adamson on the Yorkshire Boulder Committee. There is also another committee of research to which I would call your attention, namely, the Fossil Flora Committee of the Yorkshire Naturalists' Union, formed to collect and enumerate the various specimens of our Yorkshire fossil flora from the different beds in the Coal Measures. This work could be greatly forwarded if those members in a position to obtain specimens from our local strata would carefully note the exact seam or layer, and forward them to Mr. Cash, of Halifax, for examination and verification.

By a series of well-attended excursions and the aid of many clever papers, you have been able to gain a good insight into the geology of the various districts around our town; but while

duly considering the geological aspect of places outside our smoky canopy, we must not neglect as unworthy of notice those points that are ever before our eyes in our every-day work and walks; the seemingly small and commonplace materials can furnish us with prolific matter for observation and research.

The geology of the district is to a great extent illustrated in the walls and pavements of a town, and the observing geologist when passing through can tell the geological character of the neighbourhood surrounding a town. But now the exigences of heavy traffic and the requirements of the architect have introduced into the larger towns a great variety of materials from a distance, so that the amateur geologist has at hand ample material for studying many complex interesting problems, the situation of which he may be unable to visit from their distance or inaccessibility. The walls of our town, by the prevailing materials used, show at once its position to be on the Coal Measures with the Millstone Grit near, and so Leeds is placed in a very advantageous position for obtaining suitable materials at hand of such a character as are best qualified to cope with the deleterious character of its smoky and fog-laden atmosphere. From the clays and shales of the Coal Measures are obtained the bricks, and from the sandstones of the Coal Measures, and the Millstone Grit to the west, the various qualities of stone most used. The lime used in the construction of the greater portion of our houses comes from the Carboniferous Limestone to the west and the Permians to the east, and one cannot but note in passing the long rows of cottages, of which our town is largely composed, the capital character of the materials of which they are built. The number of rocks or stones from a distance, introduced to vary those of local growth, increases every year, so that we find stones of various kinds and colours in our more important and public buildings and on our main arterial roads, giving a pleasing variety of colour to the artist and an interesting collection of specimens to the geologist. In commencing a brief description of the various materials and their characters, it would perhaps be well to note the conditions under which these various geological specimens are introduced, and the various agencies with which they have to contend. The sulphurous, hydrochloric, or other acids present in the smoky air of our town greatly aid rain and moisture in attacking and destroying materials. Taking up the acid from the air, the rain spreads it over the face to carry on its destructive work. The amount of rain and wind has a considerable effect on materials; as assisted by dust the wind grinds away the face, and also forces water deep into the pores ultimately to aid the action of acids and frost. Variation of temperature is in a modified way a cause of decay, while the position of a stone

or brick in a building influences greatly its durability. That on the side of the prevailing wind and rain is most likely to decay, and any parts sheltered from the action of the sun and breeze so that the moisture cannot dry out—as in undercut mouldings and deep reveals—soon show signs of decay. Only materials, therefore, that can with any degree of success cope with and resist this action are suitable for use in such a town as ours. The best kinds of stones for building purposes are compact siliceous sandstones formed of grains of quartz cemented by siliceous or felspathic paste derived from granitic or the older crystalline rocks, and bricks of hard texture made of materials that will stand a great heat to cement and to cohere them into a semi-vitreous mass and form a hard resisting shell. Such fortunately lie at our feet, and the sandstones obtained from this neighbourhood have a high reputation over the whole of the country. There are three chief mineral constituents found in most stones, quartz, felspar, and mica, and it will perhaps be best to give a brief description of these. Quartz is one of the commonest minerals of the earth's crust, and is an essential constituent of granitic, gneissic, schistose, quartzose, and ordinary sandstones, occurring in the form of crystals, grains, or fragments. It is easily recognised by its clear appearance, hardness and glasslike fracture, and insolubility in acid. It is brittle, however, and although very hard, by no means the most refractory of minerals, and stones rich in quartz may be worked as a rule more easily than those in which it does not occur. Felspar, another common constituent of our stones, consists of silicates containing alumina with potash soda or lime. Of the various varieties orthoclase is the most prevailing, while plagioclase also frequently occurs. The felspar plays an important part in a building stone, and should be found hard and compact with few cavities or impurities, so as to resist the infiltration of water. There are two kinds of mica found; black mica (or biotite) and white mica (or muscovite). These occur in small shining scales, generally irregular in form, and exercise an important bearing upon the fitness of the stone for commercial purposes. For building stones it should be evenly disseminated through the mass in small flakes, for if in layers the rock readily splits up parallel to the laminæ of mica. The principal quarries from which our local stone is derived are in the Rough Rock of the Millstone Grit, the Elland Flagstone, and the Ganister beds and sandstones of the Lower Coal Measures, the stones from the latter being softer and "freer," or easier to work, than those from the Grit. The word "grit" as applied to our sandstones may be best defined as a tough sandstone of varying texture or grain, well cemented and strongly coherent, composed essentially of grains of silica. Where sandstones are protected

from the weather they are usually blue or grey; they then contain iron, as ferrous carbonate. At and near the surface they are of various shades of brown and yellow; this change is produced by atmospheric action converting the salt by the aid of water into one of the ferric hydrates, the tint varying with the proportion of combined water, while some also derive their colour from finely disseminated iron pyrites. Stone when first "got," or quarried, is much easier to work than when allowed to dry; this is caused by the sap—which has probably a slight amount of silica in solution—being drawn by capillarity to the face, and there drying and forming a hard siliceous skin or coating. It is best, therefore, that it should be worked before this action is completed, so that the full benefit be derived from the harder shell for its work of resistance to atmospheric denuding agencies. From Calverley Wood, Horsforth, Bramley Fall, and Meanwood, we obtain the heavier kinds of sandstone. The stones bearing the above names are coarse grained, with high crushing strain and stand weather well, the chief difficulty, so far as the builder is concerned, with the better beds of these stones being their extreme hardness. The chief districts for freestones, or close grained easier tooled stones, more suitable for the ordinary work of the builder, are Harehills, Potternewton, Park Spring, Robin Hood, Morley, and Wrosehill. Our sills, flags, landings, steps, curbs, setts, and paviors chiefly come from Bradford, Idle, Shipley, Bolton Wood, Bingley, and Halifax.

I will now briefly enumerate the different stones that may be seen in our buildings that have been imported from a distance. Granites are deservedly popular for columns and other prominent ornamental portions of buildings, and those that take a high polish are most preferred. Prominent examples may be seen in many of our churches, chapels, and public buildings. Shap granite, with which we are well acquainted in many of our erratic boulders, consists of a ground-mass of quartz, felspar, and black mica, porphyritically enclosing crystals of pinkish-red orthoclase. The red granite of Peterhead, quarried at Stirling Hill, Aberdeenshire, makes an excellent ornamental stone. It consists of red orthoclase, albite, black mica, and quartz, and is considered to be of eruptive origin. Aberdeen granite is frequently seen and takes a good polish; it is of prevailing greyish tint, of metamorphic origin, and probably more ancient than the Peterhead granite. It is composed of quartz, orthoclase, oligoclase, and black and white mica. Recently we have seen used to a great extent as dressings or ornamental portions of buildings a red coloured stone. There are two varieties used, the first "Corsehill," which is obtained from the New Red Sandstone in Dumfries. It varies in colour from bright pink to dark red, the latter beds

being the best and in use here. It is a closely grained stone, works well, and is reputed to weather well. The second is "Mansfield," quarried near Mansfield, in Nottinghamshire. This stone is a siliceous dolomite from the Permian system, and there are a variety of beds in the quarry which differ materially from one another in composition and texture, the principal being the red and white. The red, with which we are more concerned, is the most durable, and is obtainable in blocks of large sizes. It will, perhaps, be interesting to state the analysis, which is—

Carb. of Magnesia	16·10
Carb. of Lime	26·50
Silica	49·40
Iron and Alumina	3·20
Water and loss	4·80

It will be at once seen that this stone contains a high per-centage of silica much above the ordinary dolomites, and is often classed with the sandstones. It will be interesting to watch its weathering properties alongside the Corsehill and the Carboniferous sandstones. Hopton Wood stone has proved very serviceable for many purposes in our town. This stone is a fine grained compact Carboniferous Limestone quarried near Wirksworth, in Derbyshire. It will take a good polish, and greatly resembles the Nidderdale stone. There are many smaller applications of ornamental and building stones used in a modified way. These may be briefly summarised. Ancaster stone from the Oolites of Lincolnshire, and Bath stone from the Oolites, may be found, but these stones are only applicable to interiors in such an atmosphere as ours, and the experiment of using them in the open is only likely to result in disappointment. The marbles of the Devonian system, with their rich colourings and veinings, and the Mountain Limestone marbles of Derbyshire and Yorkshire, are met with chiefly in our mantelpieces, the encrinital marble of Yorkshire, and the Purbeck marble of Swanage, Dorset, being interesting masses of fossil remains. The white Carrara marble of the Jurassic age is familiar to all.

Before leaving our "walls," I will briefly touch on the subject of bricks. Bricks have been used with more effect and consideration in recent years, and it is a pleasing feature to note the now prevailing method even in our cottages, of using stone to ornament and relieve the monotony of colour. The popular idea of the material from which bricks are manufactured is "plastic clay," but many of you will recall the capital series of evening excursions to the various brickyards and pits in our immediate neighbourhood, under the leadership of Mr. Holgate, and you will remember the appearance of those pits or holes, chiefly shales, binds, with stiff clay shales. From these the fine, strong red bricks of our town, combining strength and colour, and among the finest in the

country, are made. With the method of manufacture we are not concerned, but the materials are carefully blended, so as to ensure an uniform quality and obtain the best result, each pit, of course, having its own mixture, which by experiment and experience has been found to achieve the best result. At one works two-thirds strong shales and one-third yellow clay when manufactured make a fine even-coloured pressed brick, whilst four-fifths blue shales and bind, and one-fifth ashes produce a strong, serviceable common brick. At another works one-part sand, clay, or top clay, one-part blue bind, and two-parts brown rocky shale, when ground and manufactured produce a brick that has a high reputation. The pressed bricks have the same mixture, but the materials are screened to obtain a more even texture. The fire-clay of our neighbourhood, forming the seat earth of the "better bed" coal, is noted throughout England, and it will perhaps be interesting to give an analysis of that obtained at the Messrs. Ingham & Co.'s Wortley works of the Leeds Fire-clay Company :—

Silica	82·30
Alumina	15·57
Peroxide of Iron	0·93
Lime	0·25
Magnesia	0·36
Potash	0·17
Soda	0·26
	99·84

The various kinds of glazed bricks are chiefly made from finely reduced and screened clay, burnt and glazed with pigments which are the especial pride and strict secret of each manufacturer, whilst in ornamental terra-cotta work our town is producing many very important and well-known examples. The lime with which the various materials are bound together in our buildings you are well acquainted with from our excursions to the Permians of Sherburn, South Milford, and Micklefield quarries, and to the Carboniferous Limestone quarries of Settle and Ingleton, where you saw both the raw material and the method of burning. Portland cement, so called from its fancied resemblance to Portland stone, is an artificial mixture of diluvial clay from our principal large river valleys, with certain proportions of chalk from the neighbouring districts. These materials are finely ground and mixed with "slurry," allowed to deposit, then dried and burnt, and afterwards finely ground. It is manufactured on the banks of the Humber and at Hartlepool. You had during last session a good description of the method of getting our slates in the lecture of Professor Lupton. Therefore I will only briefly summarise the districts and varieties chiefly used. The Lower Cambrian of

the Penrhyn and Bangor districts supply us with green and purple slates, while the Upper Cambrian and Ordovician beds of the Portmadoc and Ffestiniog district send the dark coloured and blue and grey slates. From the Upper Silurians of the Lake District blue and green coloured slates are obtained. These are rather thicker and heavier than the Welsh slates, but make a capital covering of a pleasant colour.

The pavements of a town offer to the downcast man but a sorry picture; but geologists are seldom, or should never be, downcast—except when studying the nature of a sett, its history and origin. The materials forming our footways and most of the carriage-ways of our less busy streets are chiefly from the grits and the flags at the base of the Rough Rock from the neighbourhood to the west of Leeds. The flagstones for the footways are evenly bedded, with a good natural cleavage, and may be riven of large size, usually micaceous on the plane of bedding, and though not so durable in wearing power as many of their competitors outside our district, have the great advantage of being most serviceable from a pedestrian's point of view, and afford a superior and firm foot-hold, whilst the durability is not much less. The chief interest of course will centre itself upon those "stranger rocks" we see now so generally used on our busy highways, and that so ably resist the great abrading action of the heavy traffic necessarily attending a busy manufacturing town. These are used in two ways, firstly, as setts or paviors on our more urban streets; secondly, as broken aggregate to form what are known as macadamised roads. Broadly speaking, any stone, or "granite" as it is generally called (though this is a term that is indiscriminately applied to all or most igneous or metamorphosed rocks used commercially) that will take on an even polish is unsuitable for the manufacture of setts, but that objection does not necessarily apply to the material used for macadam. The result is we get in the two classes an interesting variety of stone that gives us an opportunity of seeing hand specimens from districts that have been the scene of great volcanic disturbances, and so enables the amateur geologist, with the aid of these "natural illustrative diagrams," to better follow and study the physical history of districts full of interest. Among the stones used on our roads may be noticed Cockfield and Middleton whinstone; limestone; Llanbedrog, Pwllheli, Threlkeld, and Mount Sorrel, "granites;" and in places Penmaenmawr and Port Nant "granites" may be seen. The Cockfield whinstone is got from the Cockfield portion of the Cleveland, Cockfield, and Armathwaite Dyke, which commences about six miles to the south of Whitby and extends in a W.N.W. direction, crossing the Eden Valley. It is from 18 to 80ft. wide, is intrusive in the Lias and Oolites, and forms a

conspicuous feature in places. Sometimes it does not reach the the surface, but its presence has been proved by underground workings. It is a dark grey or bluish grey rock, which becomes darker after exposure to the air. It frequently possesses a sub-conchoidal fracture, and is porphyritic in texture. The porphyritic crystals are glassy-looking felspars, whole and fragmentary, and by the regularity of conspicuous ones occurring on the face of the rock it can be distinguished from the stone of other dykes. Narrow veins of calcite sometimes are found running through the rock. It is an augite-andesite, with a specific gravity of 2·77. The Whinsill of Teesdale supplies us with the Middleton stone. This rock is of similar colour to the Cockfield, and varies from a compact to coarse crystalline texture. It is micro-porphyritic in structure, with a specific gravity of 2·959, and according to Mr. J. H. Teall is very similar in its mineral constituents, though in different proportions, to the Penmaenmawr stone of North Wales. It is a diabase. Many of our members will have a recollection of this stone when we visited the quarries during the Bank Holiday excursion of 1889, and would at once see the large trade done with our town by the numerous railway trucks belonging to the Corporation standing at the quarry siding. The Ingleton "granite" will only have a brief notice. Many of you will remember that it is got at Dale Barn, Ingleton, from a bed in the Borrowdale series. It is a greyish green tough grit with a specific gravity of 2·693. The limestone for our roads is got from the Carboniferous Limestone; at Ingleton the quarry from which a portion is obtained has been fully described by Mr. Hardcastle; a great portion is obtained from the Haw Bank Quarry, which has also been the subject of one of our society's excursions. It is on the great Skipton anticline, the beds there being tilted almost vertically. It is quarried by the Leeds and Liverpool Canal Company, and is mostly black limestone belonging to the Clitheroe series. The Llanbedrog Granite Company supply from their quarries near Pwllheli, in Carnarvonshire, those light coloured Welsh stones we see on our roads. The stone is of two colours, of white and brown tint, is termed a porphyr-granite, and resembles the elvans of Cornwall. It consists of a pale grey ground mass of crystallo-granular texture, with numerous sharply defined opaque white crystals of felspar embedded in it. According to Rudler, the ground mass is composed of small crystals and crystalline grains of turbid felspar and quartz. A few irregular patches of a dark green dichroic mineral, mainly chlorite, are scattered through the base, and may have resulted from the alteration of a magnesian mica, while the chlorite itself is partly converted into epidote. There is a little calcspar, or dolomite, in the rock. Around the edges of many of the large

crystals of felspar are some beautiful examples of micropegmatite. The stone has a specific gravity of 2·53. The Pwllheli granite is a greenish grey stone, quarried at Careg-y-rimbill, or Gimlet Rock, a boss of diabase rising up out of the sea near the entrance to the harbour of the little town of Pwllheli, in North Wales. The Penmaenmawr is a well-known rock. It is quarried near Carnarvon, and is an enstatite diorite, occurring in an intrusive mass in the Upper Cambrian (Ordovician) rocks. It is quarried at two faces, the East and West Quarries. The stone got at the westerly quarry is finer, and more green in colour than that obtained from the easterly quarry. The Threlkeld stone is quarried by the Threlkeld Granite Company, near Keswick, and is commonly known as "St. John's" or "white syenite." It consists of orthoclase and microcline felspars, quartz, calcite, and a little epidote and serpentine. The felspar and quartz constitute from 80 to 90 per cent. of the whole mass, and are very hard. It is a rock closely allied to granite in composition, though differing in structure; its fineness of grain and poorness in mica render it really a quartz-porphyry. It is likely to be connected with a more closely-crystalline granite mass. The felspars have for the most part undergone slight physical change, resulting in a granulated structure which renders their optical characters difficult of recognition, but is of such a character as to better preserve a rough surface under wear. It has a specific gravity of 2·63. The Mount Sorrel stone comes from the Charnwood Forest district, a neighbourhood of great interest to the geologist. The Mount Sorrel Granite Company at their extensive workings near Loughborough, Leicestershire, prominently seen from the Midland Railway, quarry the reddish stone seen on our roads. It is an igneous rock of uncertain age, and the most noted of the Forest series. The normal rock is of a pinkish colour, consisting of quartz, felspar, black mica, and dull green hornblende, with occasional pyrite and epidote. There is also a greyer variety of rock, found only in small quantities, in which the pink tinge is nearly absent from the felspar. The rock is sometimes slightly porphyritic in structure, the ground mass becoming more finely crystalline. The red, according to Professor Bonney, consists microscopically of well crystallised quartz, felspars, biotite, hornblende, and magnetite, with a little apatite. The quartz contains minute cavities and microliths. The grey is almost undistinguishable under the microscope from the red, the difference in colour being apparently due to a different tinge in the earthy part of the decomposed felspars. It is termed a hornblendic granite, and has a specific gravity of 2·65. Each of these rocks has a history of its own, that to go into fully would be impossible within the limits of such an address as this, each one being of

itself a sufficient subject to occupy your thoughts for a considerable time. With the method of getting the various rocks and their commercial manipulation I do not intend to deal in this paper, as a description of the various quarries will furnish ample matter for a future session. The idea has been simply to place before you a general outline summary of the geology of materials you have continually under your eyes, and to try and arouse interest in a subject that from its very closeness to us has, I am afraid, been sparingly considered, in the hope that we shall observe with increased attention the scientific side of our sheltering walls and down-trodden pavements.

The evening concluded with an exhibition of lime-light views.—A hearty vote of thanks to the President for his able address was moved by Mr. C. Jefferson, and seconded by Mr. Gurnell.

NOV. 20th, 1890.

Mr. CHAS. BROWNRIDGE, F.G.S., the President, in the Chair.

"AGATES,"

BY Mr. C. D. HARDCASTLE.

(*Abstract*).

Agates are hard siliceous nodules of fine texture, transparent to translucent, formed by infiltration of silica into the cavities of various kinds of amygdaloidal trap rocks. They are inwardly variegated by bands, stripes, spots, and clouds of different colours, as red, green, blue, yellow, white, brown, and black, produced by oxides of iron, manganese, and other metallic substances. Agates receive different names in accordance with the arrangement of the bands, spots, and colours. Those which have stripes or bands of various colours, arranged in parallel lines, are called ribbon agates. The term fortification agate is applied when the parallel bands assume a zig-zag angular arrangement, somewhat in the form of a fort. Eye agate consists of a number of concentric rings surrounding a dark central spot. Moss agate is a translucent chalcedony, which appears to include embedded moss, ferns, sea-weed, small vegetable filaments, and other aborescent forms. It is sometimes called tree agate. Some of the varieties are called Mocha stone, from having been formerly supplied by traders from Mocha, in Arabia. Eminent mineralogists have differed in opinion as to whether the markings were due to embedded vegetable matter or to mineral infiltrations. The latter opinion now prevails, analysis failing to detect vegetable substances, whilst various minerals are traced in the minute

cracks of the stone, giving the appearance of ferns, foliage and moss. These markings are called dendritic or tree-shaped. Onyx is banded agate containing bands of two or more different colours. Brecciated agate contains various constituents, and often is very beautiful. Amethyst, quartz, chalcedony, and jasper are blended so as to produce contrast and harmony in a pleasing manner. It is thought by some authors that the original agate has been broken into fragments by earth movements, and subsequently recemented by infiltration of silica.

Composition of Agates.

Agates are composed of silica in its various forms. The main constituent is chalcedony, with which are associated jasper, quartz, and amethystine quartz in various proportions. Chalcedony is a mixture of crystalline and amorphous silica in concentric layers, forming concretionary masses of various peculiar forms. It has a waxy lustre, is semi-transparent to translucent, and of various colours. It often assumes a stalactitic form, but is commonly found in reniform or botryoidal masses. This tendency to a reniform (kidney-shaped) structure is supposed to play an important part in forming the curved lines in agates. Quartz in agates is pure silica, crystalline as in vein quartz, or crystallised as in rock crystal, generally occupying the centre, but occasionally forming the outer rim and intermediate zones. The strong tendency of quartz to crystallise in straight lines and form true hexagonal prisms, interferes with the circular force exerted by chalcedony and promotes the formation of irregular figures. Jasper is a compact, non-crystalline, opaque variety of quartz. The opacity is due to alteration and the inclusion of impurities. Many jaspers are sandstones altered by heat, and the colours are due to included oxides. Opal is an amorphous form of silica, containing from 5 to 12 per cent. of water. It is brittle, and has a conchoidal fracture. The apparently flinty portions of agate are rather a variety of chalcedony than flint, which is a siliceous concretion found in the Chalk.

Whence Obtained.

The river Achate in Sicily (now called the Drillo) is said by Theophrastus (300 B.C.) to have given its name to the Agate. Pliny records that agates were brought from India. Agates are now procured from various parts of the globe—Africa, North and South America, especially the Brazils, Australia, Russia and China, Scotland and Germany. The principal seat of the agate industry is the valley of the Nahe, a tributary of the Rhine. The Hundsruck Hills on the left bank of the Nahe are composed of Devonian strata. The hills at the source of the river are of volcanic origin, and consist of a kind of trap called Melaphyre, in the amygdaloidal

(almond shaped) cavities of which the agates have been formed. Agates are found in beds of similar volcanic rock in Scotland. Agates of an inferior quality have been found frequently in the drift on the east coast of Yorkshire. These, as well as the extensive supplies in the gravels of Brazil, have been washed originally out of trap rocks of one kind or another.

Mode of Formation.

It has been stated already that agates occupy cavities in amygdaloidal trap rocks. Several problems difficult of solution present themselves. 1. What is the origin of these cavities? The agate-bearing rocks were originally molten lavas emitted from ancient volcanoes. If we examine a modern lava we find that it contains a large quantity of steam which bubbles out of the molten rock as it leaves the volcano. As the lava cools and becomes more viscid the bubbles of vapour cannot reach the surface, and the rock is left full of cavities, which are elongated in the direction of the flow of the lava. These subsequently become filled with silica, sometimes in a crystallised condition, but more frequently in crystalline, amorphous, or colloidal forms. 2. Whence comes this silica? One theory is that after the consolidation of the rock siliceous material was supplied from a deep seated source, as in the case of geysers. According to another theory water containing carbonic acid decomposed the felspar in the rock itself, and deposited the silica derived therefrom in these cavities. A third theory premises that the silica was derived from the rock itself by a process of sublimation produced by heat. That the silica is derived from the strata which contain the agates is pretty certain, for the more decomposed the traps are, the richer, better, and more consolidated are the agates. 3. How has the mineral matter become deposited as we now find it in agates? Many agates show an apparent opening into the cavity at one end; sometimes there is a channel at each end of the egg-shaped mass. Through these necks it has generally been supposed that the silica has entered and spread itself by some unexplained method around the sides of the cavities in layers of different kinds and colours as successive supplies of silica arrived. This orifice has been called the point of infiltration. If the silica entered in this way, it is not easy to understand how it could arrange itself around the walls of the cavity and on the roof as well as on the floor in layers of equal thickness. A more satisfactory theory is that the colloidal silica produced by the decomposition of the felspars of the rock was introduced into the cavities by the infiltrating water, which as it deposited its chalcedonic matter passed out by the channel to make way for the transfusion of stronger solutions of silica. In some cases the deposition has evidently taken place from fixed

centres by a radiating or stalactitic process. The action of acids on gelatinous silica in the rock cavities appears to have the effect of producing slender tubes of consolidated crystalline matter, and of gradually depositing layer upon layer outwardly around the tubes until the cavity is filled, or the growth stopped by the cessation of the supply of silica. Professors Woodward and Ruskin suppose the lines and markings in many agates procured from beds of drift are the result of decomposition, since the stones were imbedded in those deposits, as is the case with banded flints. It is also believed that some of the forms of fortification and other irregularly-shaped agates have been determined by crystals of quartz formed in the cavities subsequently being dissolved, and their places filled with colloid silica.

The Agate Industry.

Agates formerly abounded in the alluvium of the Nahe Valley, but subsequently mining operations were commenced in the mass of the rock. The agates thus obtained were good but scarce. In 1827, two German emigrants to Brazil, agate cutters by trade, observed that a farm-yard was paved with agate pebbles. They collected and sent home specimens which proved so good that a trade was set up, and being sent over as ballast for ships a supply was furnished at a cheaper rate than they could be mined for in Germany. Now, although there is a protective duty on them and they are procured in the ordinary way of trade, they form the principal source of the agate industry of Europe. This industry is carried on in the villages of Oberstein, Idar, and Birkenfeld, the river Nahe and its tributaries turning the numerous small grinding mills. The red stone of the Zweibrucken furnishes grindstones, which are usually five to six feet in diameter. The stronger and coarser agates are chipped into shape with the hammer and then ground. The finer ones are cut with circular steel plates, emery powder, and diamond dust, and polished on rotating cylinders of wood or lead, moistened with tripoli. The labour of grinding is severe, two persons attending to each stone. The grinder lies on a low wooden grinding stool, with his feet firmly pressed against blocks of wood fixed to the floor. This enables him to press the agate with much force against the revolving wheel. The mill-stones rotate at the rate of 180 revolutions per minute, and the friction is sufficient to rasp down the hardest stones. About 180 mills with 750 grindstones are kept constantly employed. The artificial colouring of the stones forms a separate branch of the agate industry. It has been found that the porous bands of agate may be stained almost any colour by artificial means, while the finer and harder bands are unaffected. One method is to dry the stones thoroughly and immerse them in

oil, honey, or some other saccharine substance and water, and after a few days expose them to a moderate heat. Then after washing they are placed in sulphuric acid and again exposed to a gentle heat. The oily and saccharine matter absorbed by the porous portions of the stone is decomposed by the sulphuric acid, and a deposit of carbon produced. Colourless banded agates are thus changed into onyx. The sard, or red tint, is produced by soaking the grey chalcedony in a solution of nitric acid, water, and iron, and then heating to turn it red. Blue, green, and yellow tints are also produced by chemical means. Polished agates are made into various ornamental articles by lapidaries, and also are used in many trades. In Eastern countries they are used for inlaying marble pillars, cornices, and other portions of palatial buildings.

An interesting discussion took place, in which the President, Messrs. Howgate, J. E. Bedford, and S. Jefferson took part. The lecture was illustrated by numerous beautiful specimens, which were handed round for inspection by the members.

"A LONG-BURIED OAK,"

BY Mr. B. HOLGATE, F.G.S.

A few days ago, in making an excavation in the yard of Messrs. Tetley's Brewery, Leeds, there was discovered perhaps the finest specimen of a long-buried oak tree ever found in the valley of the Aire. It is no unusual thing to find trees buried as this has been. Such have been found in Kirkstall-road whilst digging for the sewerage; in the works of Messrs. Smith, Beacock, and Tannett, whilst digging for foundations, and in many other places. The one just found is larger than any of these, however, and presents characters which the others did not. A length of nine feet six inches only has been bared, but we are able from this to give an approximate guess at its size and mode of growth. The tree is five feet seven inches in diameter, and on it is the joint of a branch which must have been about one foot in diameter. Now if we examine a number of trees we shall find a difference in the construction, even of the same species, between those grown in the open and those grown in the forest. Those in the open spread out their lowermost branches at almost a right angle with the bole, some droop a little, and some are elevated a little. Those in the forest throw their branches upwards and grow long, straight, and slender, the tree selecting for itself that mode of growth which will enable it to present to the air for light, warmth, and moisture, the greatest area of leaf surface.

So marked is this, that when trees grow at the edge of a forest or copse, having one side in the open and the other in the wood, they grow lop-sided.

The angle at which this branch has been inserted shows that it has not been grown in an open glade, like the one at Cowthorpe or at Headingley, but amongst a number of others, and has shot upwards to seek light, warmth, and moisture among the other gigantic denizens of the forest. The stem (supposing this branch to have been the lowermost one) had been 5ft. 7in. in diameter at some 18ft. or 20ft. from the ground, and must have towered some 80ft. in height. That this was so is borne out not only by the direction of the branch, but by the closeness of the rings of growth, which average twelve layers to the inch near the bark; showing that it increased in height at a greater rate proportionately than in diameter. Such a tree must have taken six hundred years to arrive at maturity, and a further three hundred or four hundred years must have elapsed before it fell; for we find that it has a hollow interior twenty inches in diameter, and outside of this is a thickness of decayed wood.

As trees are approaching maturity they grow three kinds of wood. On the outside is a portion which is lighter and not fully formed for use as good timber, this is known as sap wood; within this is the wood of good quality, and in the centre is the part known as heart wood which is beginning to show signs of weakness and decay. As the tree increases in age the centre decays, forming the abode of and giving food to insects. The outer zone of sapwood disappears and the decaying heart enlarges, but the tree may for many years after this remain flourishing as the vital part is between the bark and the wood.

Of all woods the oak is the most useful and lasting. As in the present instance, an oak may be growing for, say 1,000 years, it may then be interred for as many times that period as may be, and when taken out and dried may be made into articles which will last for another thousand years. It possesses all the properties necessary for constructive work more than any other wood, and its cells are built up in such a way as to enable it to do this. The arrangement of its strongly-walled cells of medullary rays interweaving with its longitudinal vessels gives it strength in every direction, whilst the chemicals which it secretes render it almost impervious to decay except from within. Its bark is used for tanning leather, its juice as a mordant to fix colours in dyeing, and its wood is almost indestructible. It need scarcely be said that the sound part of this old tree is black, the inner or decayed part being of a light colour. It was not originally black, but has gradually become so through the percolation of water containing iron in solution.

What questions does the finding of this tree open up to us, not only as to its size, but as to how it came into its present position! To answer the latter, we must go back a great length of time—to a time when the Aire was a mighty river, subject to sudden and great floods, and when the country in the upper regions of the Aire Valley was covered with a dense forest growth, and inhabited by fierce and wild quadrupeds which have long become extinct. The bed of the Aire extended into Kirkstall Road, School Close, Victoria Road, Camp Field in Holbeck, the site of the Midland Goods Station, and into Hunslet Lane, no weirs nor locks held back the water, and in summer animals walked across its broad, shallow, pebbly bed. Most probably the tree has been of valley growth, and may have been snapped off by a tornado, which has torn off many of its branches, or the river may have washed away the soil from its roots. But by whatever means it has fallen, the bark has separated from it; many of its branches have evidently been severed; and at last, no doubt, it has been seized by one of the numerous and sudden floods and borne down to its present position. It has evidently been floating with the butt end down the stream, and stranded. It lies in an easterly and westerly direction, the butt end being towards the east. Some of the branches probably served as anchors, fastening it in its present position, and it has afterwards been surrounded and buried in an open sandy gravel, the pebbles of which are about one inch or one and a half inches in diameter.

But its history did not end here, for after its interment we find that another mighty flood has washed away the sandy gravel, so as to leave exposed some six inches of the stem, after which time the river became steadily filled up with coarse river sand, to a height of about six feet above the tree. Upon this has been heaped some three feet six inches by the hand of man, to raise it, no doubt, above the ordinary flood level of the river, for it is well known that up to within 150 years ago the road from Hunslet to Leeds Bridge was often impassable to foot passengers from the river being "out." At the present time the whole of the distance between Hunslet-lane and the river is of "made" earth, often filled in to a depth of eight feet. The tree is a most interesting one, and it is hoped that when Messrs. Tetley and Son have unearthed it, as they intend doing, more may be learnt about it.

ADDITIONAL NOTE BY Mr. HOLGATE, JUNE 30TH, 1891.

Since writing the above, Messrs. Tetley and Son have, at great trouble and cost, endeavoured to unearth this tree. They

proceeded to dig in an easterly direction towards the root end, and then had to saw it where it lay.

They drew out a length of 23ft., the weight of which was 13 tons.

In the whole length taken out there was only a difference of six inches in diameter between the two ends, and in this length the junctions of four branches were seen. The lowermost was six feet from the eastern end, and twenty-one inches in diameter; the second, nearly opposite to it but a little higher up the tree, was eighteen inches in diameter; the third, the one alluded to in the former description, was twelve inches in diameter, and the fourth was still higher up.

The tree was hollow in the centre and three of the branches were also hollow to a certain extent. The lowermost must have been broken off before the tree fell, and it is very probable that the tree itself fell from internal decay at the base which must have been some distance lower down.

These additional facts more than prove what was said of the tree previously. It must have been about 100 feet in height. Each of its lower limbs was as it were a tree in itself, and this old oak affords one more proof of the immense forest growth which existed in very early times in the valley of the Aire.

DECEMBER 18th, 1890.

Mr. J. E. Bedford, F.G.S., Vice-president, in the Chair.

The Rev. E. Jones was to have read a paper on "Bone Caves," but unfortunately during a recent visit of investigation to the caves for further information in explanation of his intended paper, he had caught a severe cold and was confined to the house. It was decided to occupy the evening with an

EXHIBITION OF LANTERN SLIDES

of geological interest.—The Chairman reported to the meeting that the Adamson fund had been closed, and the special committee appointed to deal with the subject had dealt with the fund, which amounted to £176 19s., in a very satisfactory manner. The various slides exhibited were from the collections of Messrs. J. E. Bedford, Godfrey Bingley, A. B. Gill, Thomas Dawson, J. Ingleby, J. Ramsden, G. H. Rodwell, T. W. Thornton, and A. E. Nichols, some 450 in all, and included views in the British Isles, Norway, Sweden, France, Switzerland, and India. Many of the slides were of especial interest, and discussions were frequently raised on the geological phenomena illustrated, whilst one of the members distinguished himself very much by his intimate knowledge

of the intricacies of the Cymric vocabulary during the exhibition of a fine collection of Welsh views. Among the slides shown were fine illustrations of the denuding agencies of the sea, wind, frost, rain, &c., while the violent agencies which have been at work on our earth were well illustrated by a series of views, showing curved and contorted strata in all forms. Good views were shown of the effects ice and snow have left. Slides of erratic boulders of all shapes and sizes were shown, as also of glaciers in which medial and lateral moraines were clearly marked, these glaciers being fed from the snow fields, some of which are upwards of 800ft. thick. From these views a very good idea may be formed as to how the rocks below are scratched and rubbed, and also how large pieces of rock are broken off the sides of the mountains, carried for miles from their original homes, and deposited as erratic boulders. The views of Norway were greatly admired, and showed some of the finest mountain scenery of its kind in the world. Other slides took the audience in imagination to the most interesting and charming valleys and hills in the country, in which the four seasons were shown in all their beauty, it being difficult to say which special time of the year showed off to best advantage. One view occasioned great interest, as probably few people have had an opportunity of seeing a similar photograph before. This was a view of a tiger taken from life in the jungle just as he was awaking from sleep. The splendid animal is laid at full length, and has just raised his head, the eyes being still partly closed, evidently with a feeling of perfect safety in his home. In taking this view, it was explained, the photographer took off the cap, and after replacing it decamped with all speed in one direction, whilst the tiger did the same in the opposite direction.

A cordial vote of thanks was accorded to the gentlemen who had lent the slides. A.E.N.

JANUARY 15th, 1891.

Mr. CHAS. BROWNRIDGE, F.G.S., the President, in the Chair.

"THE BACKBONE OF ENGLAND,"

BY Mr. J. E. MARR, M.A., F.R.S., Sec. G.S.

(Abstract).

The history of the Pennine Chain naturally includes that of the surrounding country, which has been affected by the same set of movements; consequently, in discussing the changes which have resulted in the formation of the range, we are to a certain extent examining the history of the county of Yorkshire. The lecturer took up the subject at the period subsequent to the

deposition of the Lower Palaeozoic rocks, their folding, and the erosion of a plain of marine denudation, upon which the Carboniferous rocks were deposited horizontally, to form a plain of sediment near the sea-level. Out of this plain the rudiments of the Pennine Chain arose by the production of a simple anticlinal arch, formed before the deposition of the Permian beds as evidenced by the strata on the east side of the ridge. A somewhat detailed consideration of the character of the changes produced during the deposition of the Permian rocks, led the lecturer to conclude that during Permian times the north of England was broken up by a set of monoclinal faults into great blocks of country, somewhat similar to those now prevalent in parts of the north-west territories of North America. Among the features which he considered had been produced by this differential movement was the depression of the tract now occupied by the Eden Valley, and the deposition of the New Red Sandstone rocks of that region in an area of special subsidence. He gave reasons for supposing that Morecambe Bay was a similar area of depression in these times, and compared the changes which had taken place with those which had been held by Professor Brogger to be accountable for the outlining of the Christiania Fjord. From an examination of the Rhætic deposits of Carlisle and the east of the Pennines, it was considered that this folding might have gone on through Mesozoic times. The structure of the Lake District was considered, and compared with that of the Henry Mountains of North America, and it was suggested that the Lake District dome was of laccolitic origin, but that the newer rocks, which had determined the radial trend of the drainage, had since been entirely denuded from the central parts of the district, causing the impress of a superinduced drainage upon the Lower Palaeozoic rocks. Compared with this complex area of drainage, the drainage of the Pennine Chain was seen to be comparatively simple, the watershed having been determined by the crest of the anticlinal, though it is now merely parallel and not coincident with this, owing to the operation of the law of lateral shifting of watersheds with unequal slopes.

Thus had the sculpture of the north of England proceeded, both fluviatile and marine denudation producing greater effects on the soft rocks, and so causing the depressed areas of the Eden Valley and Morecambe Bay, whilst the harder rocks still stood out, as the Pennine Chain and the Lake mountains, and comparatively narrow valleys only had been carved out in these. The lecturer maintained that the valleys of the latter areas might also be, geologically speaking, modern, and that they need not date farther back than the Tertiary times. The last stage in the history of the area was its occupation by ice in the glacial period, and the lecturer

stated that he felt it unnecessary, after the work of Messrs. Tiddeman and Goodchild, to adduce any further arguments in favour of the existence of an ice-sheet. Most of those who appealed to floating ice to produce the phenomena of glaciation had not studied the area, nor yet a modern region occupied by an ice-sheet. By reference to the works of the Danish Commission appointed for the exploration of Greenland, it was shown how, during the period of maximum glaciation, the highest points of the Pennines would stand out as islets (Nunataks) from the great ice-sheets which would flow round them, producing conflicting currents of ice, and thus cause the intercrossing of erratics. It was also pointed out that contorted stratified deposits were actually formed in the ice of Greenland, and could not always be appealed to as evidence of milder climate or of marine conditions. In conclusion, the lecturer maintained that, contrary to what was usually stated, the history of the district was not a fragmentary but a continuous one, if only we studied physical changes as well as strata, for we could fill up gaps in the succession of the latter by an appeal to the former; and he drew special attention to the development of the drainage of a region as an important bit of evidence in drawing up such a history. He maintained that the Pennine Chain well deserved the appellation which he had used as the title of his lecture, for it was the "backbone" of England in more than one respect. Physically it formed a part of the framework against which the newer rocks of the island were deposited; the foldings which had produced it had also folded the Coal Measures into such positions that the coal was readily extracted and made to minister to the country's wealth; and, lastly, the changes which had gone on during the building of the Pennine Chain had produced a set of physical conditions which had largely influenced that sturdiness of character which marked the dwellers on either side of the Chain, a sturdiness which was in fact the backbone of England's greatness.

At the close of Mr. Marr's able and eloquent lecture, a hearty vote of thanks was moved by the Secretary and seconded by Mr. William Cheetham, who spoke from personal knowledge of the areas described, and expressed his high appreciation of the lucid and suggestive manner in which the lecturer had treated his subject. The lecture was illustrated by diagrams and photographs exhibited by Mr. J. E. Bedford's lime-light lantern.

FEBRUARY 19th, 1891.

Mr. CHAS. BROWNRIDGE, F.G.S., the President, in the Chair.

"A GEOLOGICAL EPISODE, AS RECORDED IN THE INGLETON GRANITE," BY Mr. THOS. TATE, F.G.S.

(Abstract).

The bed of rock known as the "Ingleton Granite," forms part of a series of marine deposits, some 30,000ft. thick, originally laid down continuously in a horizontal position, but now leaning down to the south, having been thrown well-nigh on end by the Caldbeck anticline. They may be seen arching over the central granite beds of this anticline on Caldbeck Fells, and beyond this dipping to the north towards Solway Firth. The numerous examples of false bedding, sun-cracks, and ripple marks found in these beds indicate that they were accumulated in shallow water; but such an enormous thickness of sedimentary deposits could only have been piled up over a subsiding sea floor. And conclusive evidence of such a continuous subsidence at that time of the Archaean rocks now forming the foundations of the European continent is forthcoming. In the south-west area, all about Central Spain, where the depression is at its maximum, we find a series of eight life-groups succeeding each other in ascending order, entombed in deposits, whose base rests upon these Archaean rocks. Passing to the north-east from Spain by way of Sardinia, Bohemia, and the northern shores of the Black Sea, thence to the Ural Mountains, we gradually miss the early deposits, with their characteristic life-groups, these disappearing in the order of their sequence, so that by the time we reach our final station only the latest group is met with. A like result follows a traverse, say from Wales by Sweden and Finland to the shores of the Arctic Ocean, to the east of the White Sea. The direction in which the sea encroached is thus evidenced by an examination of the order in which the deposits were thrown down, and of the successive faunas found therein. In a paper read during the recent meeting of the British Association, Mr. Tate adduced proofs of the fragmentary rather than crystalline origin of the Ingleton Granite, and it is now universally admitted that, scientifically speaking, it is not a granite. He therefore proceeded to apply to this deposit the petrographical method for the identification of rock-fragments and the determination of their mineral components, by means of the optical behaviour of their crystals in thin sections under the microscope—a method of research to which he first directed the members of this society in 1879, since which time he has thrice

exhibited to them its practical utility. Microscopically examined, the Ingleton Granite is seen to consist of fragments of various metamorphic, as well as of eruptive and pyroclastic rocks. The slides submitted to the inspection of the members exhibited slates; chlorite, mica, and quartz schists; pegmatite; quartzose and granitoids, together with ancient rhyolitic lavas showing banded, fluxion, and spherulitic structures. Some of the latter held porphyritically developed crystals of remarkably clear sanidine, and of quartz enclosing portions of the felsitic ground-mass. All these various rock-fragments are firmly bound together by a cement of green diabasic paste with very fresh lath-shaped crystals of plagioclase; and more basic minerals, probably augite and olivine, now converted into secondary products, such as chlorite and epidote. The majority of the fragmentary ingredients of this clastic rock are so little waterworn, and the attrition to which they have been subjected has been so very slight, that it is clear the land whose denudation supplied materials for the building up of this rock lay at no very great distance from the spot where we now find its ruins reconsolidated. Its deposition formed an episode in the prevailing volcanic conditions of the period, and consequently we find it sandwiched between beds of greenish-grey slate, consisting of a fine felspathic volcanic dust, which is never a constituent of the granite itself, although it is interbedded with it on one or two horizons.

At the close of Mr. Tate's lecture, several of the members asked questions which served to bring out further information on this important Yorkshire bed. The meeting concluded with a hearty vote of thanks to the lecturer for this interesting account of his investigations on the Ingleton Granite.

MARCH 19th, 1891.

Mr. CHAS. BROWNRIDGE, F.G.S., the President, in the Chair.

"FROM KETTLENESS TO SALTBURN,"
BY Mr. EDWIN HAWKESWORTH.

(*Abstract*).

"Know most of the rooms of thy native country before thou goest over the threshold thereof, especially seeing England presents thee with so many observables," says Fuller; and this is equally true if Yorkshire be substituted for England in the extract. We have to consider the coast of Cleveland or "cliff-land," the most northerly part of our county; a strip of coast about twelve miles in length, trending almost east and west. From the Yorkshire coast there runs in a south-westerly direction through the counties of

Lincoln, Nottingham, Leicester, and Gloucester, to the cliffs of Lyme Regis and Durlstone Head, in Dorset, a thin strip of rocks. They consist of clays, shales, limestones, sandstones, and ironstones, named by William Smith, "the father of English geology," Lias, said to be derived from the local pronunciation of the Somersetshire quarrymen of the word "layers." In Yorkshire the Lias formation reaches a maximum thickness of 1,200 feet. The beds have a gentle dip to the south-east, and crop out in a curve which extends from Redcar to the Humber. The formation is well exposed on the Yorkshire coast, the whole series except the lowest beds being accessible for study. The Lias is divided into upper, middle, and lower divisions, but owing to the fact that almost every writer upon the subject makes the dividing lines in different places, they are not of much use. Dr. Oppel, a German geologist, after studying these rocks both in England and abroad, found that they could be divided into 13 distinct "zones," each with a more or less peculiar assemblage of fossils, in each of which a characteristic form of ammonite is found from which the zone receives its name. The Yorkshire Lias is distinguishable from that of other areas by several well-marked lithological differences, such as the vast number of nodules or doggers, the abundance of ironstones, sandstones, and limestones, and the fact that none of the latter are pure.

Kettleness terminates the eastern cheek of Runswick Bay, and its summit is about 400 feet above the sea-level. The view from the summit is very fine. Hundreds of feet below lies the rocky shore, upon which, as the restless sea recedes, long lines of scars are exposed to view. Out to sea, many a white sail gleams in the sunshine; whilst to the west the eye sweeps round the beautiful bay of Runswick—a picture whose magnificent scenery furnishes many an artist with good subjects. The cliffs here are capped by sandstones of the Lower Oolites, which towards the lower part contain bands of hard, impure ironstone, known as "the dogger." This rests upon the alum shale beds (A. communis) of the Upper Lias. The alum shale, in days gone by, furnished material for a considerable industry in this part of our county, and now old disused alum works are found at several points along the coast. The story runs that the manufacture of alum was introduced into England early in the seventeenth century by Sir Thomas Chaloner. When travelling in Italy he had seen the rocks from which the Italians extracted alum, and riding one day near Guisborough, he noticed that the colour of the foliage resembled that of the trees in the alum districts abroad. Soon afterwards he commenced alum works in the hills near that town, sanctioned by a patent from Charles I. One version has it that he smuggled over from the Papal States, concealed in casks, workmen who were ac-

quainted with the manufacture, and was excommunicated by the Pope for this breach of his monopoly. Common alum is a double sulphate of alumina and either ammonia or potash. Shale is largely composed of silicate of alumina; the alum shales contain in addition much sulphide of iron, and thus by calcination the sulphate was formed. This was washed out by water, and the liquor being evaporated, a salt of potassium was added, which precipitated the alum. This was for a considerable period the only natural source of alum; and, notwithstanding the inaccessibility of the district and the distance from fuel, the industry flourished until about forty years ago, when Peter Spence found that alum could be obtained as readily and more cheaply from the Coal Measure shales, and the ammoniacal liquor from gas works. Thus the industry was gradually exterminated; but it has left abundant evidences of its magnitude in the shape of old works, gigantic excavations in the cliffs, and enormous heaps of refuse. The shale is of a blue colour, readily breaking into small, thin fragments, and on exposure to the air gradually becoming encrusted with sulphur.

Fossils are not abundant at Kettleness, but in most exposures they are found plentifully, though the number of species is small. The most remarkable are the reptilia and the cephalopoda, one species of the Teleosaurus, and three species each of Ichthyosaurus and Plesiosaurus being known. It seems remarkable that whilst in the south of England most of the Liassic reptilia are found at the base of the formation, in the north they are found in the upper part. A few yards lower down the cliff we come to the next zone, that of A. serpentinus, locally known as the jet-rock. The top bed is a hard, smooth, friable shale, succeeded by a strong, compact, bituminous, shaly rock, in which occur large cheese-shaped masses containing jet. These shales, besides being highly bituminous in parts, also contain large quantities of iron pyrites, often causing them to spontaneously ignite. It has been computed that ten gallons of oil could be extracted from one ton of the shale. The fossils in this zone are highly interesting, large numbers of fish and reptilian remains having being found. It is the great repository of Liassic fishes, which chiefly belong to the genera Pachycormus, Ptycholepis, Leptolepis, and Gyrosteus. It is also the only portion in which the Aptychi, or opercula, of ammonites are known to occur. The formation of jet has never been satisfactorily explained. Some writers maintain that it is a variety of coal, but it exhibits no vegetable structure. Others claim for it an indirect vegetable origin, considering it to be derived from bitumen which originated from vegetable matter embedded in the shales. But considering the rarity of plant remains in these shales, it seems more reasonable to look to an animal source, such as the fish remains, for the origin of the

bitumen. Jet as a suitable substance for the manufacture of personal ornaments has been known from very early times, beautiful examples having been found in coffins of Roman age and ruder ones in Celtic barrows. For a length of time the source of supply was the shore, but in recent times jet has been mined. This is a dangerous and precarious occupation. There is nothing to guide the worker except the level, and sometimes he may toil for months and not find enough to pay for powder and candles. The jet-diggers usually drive a headway into the cliff or hill side of a sufficient size to admit of a man wheeling a barrow, and from this they make smaller passages. Underlying this bed is the zone of A. annulatus, which in its turn rests on that of A. spinatus, better known as the Ironstone series. These rocks form the base of Kettleness, and some of the earliest cargoes of Cleveland ironstone were obtained from this spot.

About half a mile from Runswick is Rosedale Wyke, from which large quantities of ironstone are shipped. This stone is found at its best at Eston Nab, eight miles inland. In this district two seams are conspicuous by their thickness and quality —the upper one known as the Cleveland main seam and the lower one as the Bottom seam. The Cleveland ironstone is a greyish-blue earthy rock, porous, and more or less oolitic, composed of carbonate of iron with earthy admixtures, and yielding as a maximum from 30 to 32 per cent. of metallic iron. This zone is highly fossiliferous, and it is worthy of note that where the stone is at its best there the fossils are most numerous. As to its origin, Dr. Sorby concludes that "the Cleveland stone was a kind of oolitic limestone, inter-stratified with clays containing a large amount of oxide of iron and organic matter, which by their mutual reaction gave rise to a solution of bi-carbonate of iron; that this solution percolated through the limestone, and removing a large part of the carbonate of lime, left in its place carbonate of of iron—and not that the rock was formed as a simple deposit at the bottom of the sea." The walk to Staithes is very fine, the weed-covered scars and grand cliffs presenting splendid opportunities to the geologist. At Brackenberry Wyke, a small bay girt with lofty cliffs, a fault is recorded, which is now completely obscured; but at Old Nab the main seam emerges from the talus, forming a well-defined terrace. In the next opening, Jet Wyke, these beds rise up into the cliff, until at Staithes they are near the summit at an elevation of 150 feet.

From Staithes to Loftus-in-Cleveland there are the most lofty cliffs in England, being at Boulby 666 feet high. At Loftus we have the coarse earthy shales of the zone of A. Capricornus, with nodular bands running through them. This part is noted for the variety of starfish remains, and a great many of the known

forms of Liassic foraminifera are found in the softer parts of the shales. On our way to Saltburn we have to round one of the finest points on the Yorkshire coast, Huntcliff, which rears its lofty head 380 feet above sea-level. Round Huntcliff Point is a scene of the wildest confusion, the shore being covered with huge blocks of stone. As we go on the cliffs rise perpendicularly, and in some places overhang. Still nearer Saltburn, the Liassic beds sweep inland, and their place is taken by huge cliffs of drift. Leaving the beach at Old Saltburn we come to a pyramidal hill called Cat Nab, composed of boulder clay. It is simply an outlier from the cliffs on either side, the land behind having been cut off by two streams. There is ample field for the geologist in the Skelton and Saltburn valleys, excellent sections being given. In the Saltburn valley there is a section of one of the few instances of contortions in the Lias. Such is an outline of a walk which for grandeur of scenery and geological interest combined it would be hard to find a rival.

Mr. Hawkesworth's interesting paper was illustrated by a number of views and sections, and at the close a hearty vote of thanks was accorded to him, and also to Mr. J. E. Bedford, F.G.S., for the lantern accompaniment.

APRIL 16TH, 1891.

MR. WILLIAM CHEETHAM, Vice-President, in the Chair.

"THE GEOLOGICAL HISTORY OF ENGLAND,"
BY Mr. W. LOWER CARTER, M.A., F.G.S.

(*Abstract*).

This paper was prepared at the request of the Council to set forth the results of modern theorising on the physical restoration of Britain during successive geological periods, and a special feature was its illustration by a series of slides prepared by Mr. A. E. Nichols (Assistant Secretary) from Mr. A. J. Jukes Browne's "Building of the British Isles," on which the paper was based.

In commencing the lecturer apologised for the dogmatism of the paper which was a necessary fault of so short an abstract. The history of a nation is the record of a continuous development but the historian naturally seeks for a series of landmarks by which he may conveniently divide his subject into eras. Some such divisions may mark points at which definite changes in constitution or polity took place, whilst others may be adopted principally for convenience' sake. So also in attempting to delineate the geological history of England, the interpreter of the rocky annals divides his subject into periods, some of which

point out epochs of revolution, whilst others are merely convenient landmarks in the gradual development which went on age after age without any cataclysmic disorder. The earliest ages of a nation's life are always more or less hidden by the mists of uncertainty, and are fruitful of legendary and mythical lore. So also the facts of pre-carboniferous geological history are few and admit of a considerable use of the imagination in their interpretation.

Beginning at the earliest geological records, the Archaean rocks, we are introduced to gigantic earth disturbances, with great volcanoes emitting lava and ashes in abundance, whilst thermal springs, highly charged with calcareous salts, formed lenticular limestone deposits. The close of this period was one of extensive erosion, which formed the immense thicknesses of the Cambrian grits and conglomerates, and brought to light the deep-seated igneous and metamorphic rocks which had formed the foundations of the old volcanoes. At the beginning of the Cambrian period a great continent appears to have occupied the North Atlantic area, whilst in Europe there was more land than sea. The surface of the earth was very rugged, consisting of great mountain ranges, separated by very deep valleys. In one of these troughs the Welsh Cambrians were laid down against a steep slope inclining in a south-easterly direction. Dry land lay over the West Midlands, and another island mass occupied the site of the Irish Sea. During the formation of the Upper Cambrian and Ordovician beds there was a submergence of the western and northern parts of the British area, whilst an upward movement formed a large central English island, eighty miles long, from Charnwood to Malvern. Various oscillatory movements took place during Silurian times, but at the beginning of the Old Red Sandstone a rapid elevation united the British area with the North Western Continent. The sea, in which the Devonian beds were deposited, extended from Ireland over southern England into France and Belgium, and a long estuary stretched northward over Wales and Shropshire. Northern Britain was intersected by several mountain ranges running from south-west to north-east, between which were low-lying tracts of land which at first formed inlets of the sea, but afterwards became large lakes. Owing to continued elevation the excurrent rivers were able to deepen their channels, and the lakes became drained, forming wide sandy plains between lofty mountain ranges. Depression again caused these basins to be filled with water; torrents washed down large quantities of screes, and the Upper Old Red beds were formed.

During the Carboniferous period a great continental area extended from the Rocky Mountains across the North Atlantic to Finland. The chief British island lay over St. George's Channel, stretching northward into western Scotland, and eastward

through Wales to the Midlands. The Carboniferous rocks were laid down in a land-locked sea studded with islands, having deep depressions in the central portions in which the great thicknesses of limestone were deposited. Gradually these deep basins became filled with calcareous growths, and an elevatory movement enabled the mixed deposits of Yoredale sandstone, shale, and impure limestone to spread far and wide. Gradually the outlets of the sea became silted up, and an immense fenland was formed, with large lagoons in which delta deposits were accumulated. The great masses of coarse Millstone Grit are so distributed as to suggest that they were formed by the denudation of the steep slopes of St. George's Island during a rapid upheaval. The Coal Measures were accumulated during a gradual subsidence, in which Europe became one vast swamp, silted up by tremendous denudation from high mountain lands. At the close of this period great earth throes took place, resulting in the depression of the northern Atlantic continent, and the elevation of a European continental area. A great inland sea like the Caspian was formed, with the Pennine Chain as its western shore line, in which evaporation was great, and the Magnesian Limestone deposits were formed. Westward of this sea lay a large lake, on the north side of which extensive volcanic outbursts took place. An elevation at the close of the Permian period converted these lakes into desert land. A considerable submergence in the Alpine region enabled the Muschelkalk limestone to be deposited. During Bunter times sandstone and shingle beds were laid down in three separate areas in Britain, which were either lakes, or, as is more probable, subaerial delta deposits on desert plains adjoining mountain ranges, such as are now formed in India, Persia, and Abyssinia. A depression at the beginning of the Keuper period altered the drainage, so that the rivers discharged themselves into depressed areas and formed large lakes, one of which extended from Normandy through central England, and was divided by the Pennine Chain into two branches. A gradual submergence enabled the Jurassic ocean to advance from the south-east, rapidly filling the lake basins and destroying the Triassic fish and reptiles, as shown in the Rhætic bone-bed. Submergences at intervals brought the Coal Measure shales thrice under denudation, and the Lias, Oxford, and Kimeridge clays resulted. During the intervals of rest the rivers cut down their channels to the Carboniferous Limestone, and conditions favourable to the growth of coralline deposits took place. An upheaval caused the formation of the Wealden lake, which was fed by great rivers from the north-west, and a ridge was formed across eastern England. Submergence during the formation of the Upper Wealden beds converted this lake into an inlet of the southern sea, whilst another gulf extended

north of the central ridge into York and Lincoln. Further submergence enabled the waves to cut through this ridge, and a narrow strait united the Speeton and Wealden gulfs. Continued depression took place in Upper Cretaceous times, carrying the Gault over the whole of south and east England; the shore-line then extended northwards from Wales to the Pennine Chain, and land united Scotland with Scandinavia. Further submergence converted the highlands of Cornwall, Wales, Yorkshire, and Cumberland into a group of islands, and oceanic conditions prevailed over the whole British area.

At the close of the Cretaceous epoch an elevatory movement united Britain with Europe on the one hand, and with Iceland and Greenland on the other. Great plains of chalk stretched over the greater part of England and Ireland. Volcanic activity, which often accompanies elevation, was shown in great outpourings of basaltic lava in Ireland, Scotland, Faroe, Iceland, and Greenland from great volcanoes. The Mull volcano was probably larger than the modern Etna. The existence of valleys, water-courses, and river-beds in these volcanic districts shows that the country was watered by copious rainfall, whilst the lower slopes of the volcanoes were clothed with abundant vegetation. A gradual depression over Belgium brought the Eocene sea over England. During the deposition of the Thanet Sands the Thames estuary would be part of a large bay with low shores lined with sand-dunes. The Wealden area began to rise early in Eocene times, first forming a shoal, and then a low island without cliffs, which would afterwards be developed by marine denudation. Continued submergence enabled the sea to advance westward until its shore-line was formed by the Chalk stretching from Marlborough eastward over the Fenland, and large rivers brought down the London Clay. At the commencement of the Oligocene period England, Ireland, and Scotland formed one mass of land with France. A great upheaval over Western Europe united our area with Africa. The mountainous regions in the west of England and Ireland gave rise to great rivers, one of which emptied itself into an estuary which stretched from Paris into Hampshire. Its banks were clothed with tropical vegetation, and shallow lagoons teemed with crocodiles, turtles, &c. A general upheavel brought in the Miocene epoch, during which considerable denudation took place over Britain. Subsidence in early Pliocene times enabled a German Ocean to advance over eastern England, but a land barrier shut out the Arctic Ocean. A considerable upheaval then raised the Coralline Crag into dry land, and united Britain, France, and Belgium into a broad mass of land, which stretched to Greenland. A local depression formed the basin of the North Sea. The Red Crag was accumulated in a shallow sea studded

with reefs of Coralline Crag. The gap in the Chalk which we know as the Wash was probably made by the combined rivers—Trent, Witham, Welland, and Nen—which flowed in a broad valley before the escarpment had receded to its present position. At the time of the Forest Bed the North Sea probably was a broad plain traversed by one large river, the Rhine, which formed a great estuary.

An upheaval at the opening of the Pleistocene period restored land connection with Greenland, and favoured the formation of snow and ice in our latitudes. The early glaciation of Scotland and northern England was now accomplished by confluent ice-sheets. Subsidence then took place until Britain became a group of islands. Gradual elevation followed, and the mountains once more became covered with snow and ice, and local glaciers were formed, but the lower ground was free from snow and tenanted by numerous mammals. The whole of Britain then would stand about 300ft. higher than at present and was united with France, allowing of the incoming of Palæolithic man and the mammals that co-existed with him. The Dogger Bank was a plateau in a wide level tract over which the Rhine made its way northwards, while large rivers flowed westward down the valleys of the Bristol and English Channels. St. George's Channel and the Irish Sea were an area of low-lying land formed by a local subsidence, along which several lakes lay, which, with their ex-current river, formed the boundary between Ireland and Great Britain. A gradual subsidence of this region to the 40 fathom line would enable the sea to advance some distance along the English Channel and North Sea. The lakes in the Irish Sea area would become a long narrow inlet of the Atlantic, the connection between Ireland and Scotland being reduced to a narrow isthmus, which soon would be cut through. Further submergence converted the Dogger into an island, and enabled the advancing waters to meet over the lowest part of the chalk watershed near Dover. Before this separation was completed Neolithic man had probably taken possession of the country, and Palæolithic man and many mammals had become extinct. The last period of subsidence in the south of England seems to have been combined with an upheaval in Scotland which brought the general level of our country to its present condition.

The geological history of England is not yet completed. A new chapter is being written in our days. The study of the past leads us to expect changes in the future, which may again unite Britain with Europe. The lesson of the present, with its gradual changes, should teach us that the geological history of England in the past has not been a series of convulsions separated by quieter periods, but a slow process of evolution, the most rapid

changes of which were immensely slow compared with the life of man, and such we may expect the future development to be.

The paper was followed by a short discussion, in which several of the members took part, and cordial votes of thanks were awarded to the reader and also to Mr. Nichols for his excellent illustrations.

APRIL 30th, 1891.

Mr. CHAS. BROWNRIDGE, F.G.S., the President, in the Chair.

EXHIBITION OF SPECIMENS.

On Thursday, April 30th, an extra meeting of the Association was held, in order that there might be an exhibition of specimens by the members. Only a few responded to the invitation sent out by the Council, but some interesting collections were shown. After the disposal of the preliminary business, the President suggested that the meeting should take a conversational form, and that the exhibitors should be asked to describe their specimens in turn. Mr. William Cheetham brought a series of photographs and minerals from the French Pyrenees, which had been specially forwarded for the Association by Miss C. Whitley, of Chateaurenault. Among the minerals were crystals of iron pyrites and argentiferous lead, and specimens of the metamorphic rocks of the locality. Mr. Cheetham also brought specimens of the ice-scratched boulders, beautifully smoothed and striated, which have been found during the excavation of Winterburn Reservoir for the Leeds and Liverpool Canal storage water. The largest, he said, would probably weigh three tons, and was considered by Mr. Tiddeman to be one of the finest boulders in the north of England. Mr. Cheetham suggested an excursion of the Association to this locality at an early date. Mr. B. Holgate, F.G.S., sent a series of photographs of the giant oak lately found in Hunslet. The President informed the Association of two fresh boulders from the clay above the Better Bed coal. One of them, was pronounced a quartzite; the other had not yet been determined. He also brought some fossil sponges from the Chalk of Bempton cutting, near Bridlington, and goniatites from the Yoredale beds. The latter, he said, were found in hard, compact concretions, from which they were most easily disengaged by heating to redness, and then plunging into water. The concretion would then break up easily under the hammer, and usually the fossil came out in good condition. Specimens from the Lias of Whitby were shown by Mr. S. Halstead. Mr. Carter brought a collection of fossils from the Cambridge Greensand, including fish and reptilian vertebrae and teeth, corals, sea-urchins, ammonites, &c. The

fossils, he explained, were obtained from what is known in Cambridgeshire as the "Coprolite bed," which lies at the bottom of the Chalk Marl on an eroded surface of Gault. This bed is not a true greensand deposit, but is a thin stratum, barely a foot in thickness, full of black nodules, and casts of organisms very rich in phosphoric acid. When ground these concretions form a valuable artificial manure, and as much as £100 per acre has been paid for the privilege of digging them. The bulk of the fossils are not proper to the bed, but are derived by denudation from the underlying Gault. Mr. E. Hawkesworth brought a good collection of specimens from the Lias of the Yorkshire coast, including many good examples of ammonites and belemnites. One of the latter was splendidly preserved, exhibiting the ink bag (analogous to that of the cuttle fish) attached to the phragmacone and guard. An account of an interesting antiquarian discovery at Bingley was graphically given by Mr. Cheetham. In digging for the foundations of a new bank there had been found, 14ft. below the surface, an old anchor of good workmanship, and not much corroded. This awakened considerable speculation, and it was felt that the matter ought to be investigated, on the chance that something interesting might come to light with regard to the Flood and Noah's Ark. Mr. Cheetham went over to see the site, and found the depth as reported, but the ground was all blackened, for which he could not account. That portion of the Aire was once the outlet of a great lake, and Bingley is built on boulder clay, so evidently there was room for careful investigation. The name of the site was Elm Tree Hill, but on investigating the length of time which must have elapsed since elm trees grew there, he received the valuable and luminous information that it was the old Elm Tree Inn from which the name was derived. Further enquiry along the same lines revealed the fact that seventy or eighty years ago there had been a blacksmith's shop on that site, and the excavators had penetrated into the recesses of his cinder tip!

The meeting closed with a vote of thanks to the exhibitors, and to Miss Whitley especially for her contribution from the Pyrenees.

MAY 21st, 1891.

Mr. CHAS. BROWNRIDGE, F.G.S., the President, in the Chair.

"THE LIFE HISTORY OF A VOLCANO,"

BY Mr. W. LOWER CARTER, M.A., F.G.S.,

(Abstract).

At this meeting Mr. S. Chadwick, F.G.S., was announced to read a paper on "Flint from the Yorkshire Chalk," but, unfortunately,

was unable to fulfil his engagement. In his absence a lecture on "Volcanoes" was given by the Hon. Secretary (Mr. W. L. Carter), illustrated by a large number of beautiful lantern slides.

What is a volcano? The old answer was, "A burning mountain, from the summit of which issue flames and smoke." This, the lecturer said, was a misconception from beginning to end. A volcano is essentially an opening in the earth's crust communicating with the heated interior. The volcanic mountain is the mass of materials which has been ejected from this aperture. A volcano does not burn, *i.e.*, there is no combustion at the summit, but it emits large quantities of steam and fine ash, which together form the so-called smoke, and streams of white hot lava, the flashing light from which reflected by the overhanging clouds looks like flame. The name "volcano" comes from the Island of Vulcano, near Sicily, which was styled by the ancients "The Forge of Vulcan." This volcano is now fairly quiescent, and a chemical works was established in the crater some years ago, by an enterprising Scotch firm, for the condensation of the sulphurous and other chemical fumes which it gave off. One night, however, an eruption took place, blowing the manufactory into the air, and effectually stopping that branch of industry. One naturally turns to Italy for examples of volcanoes, because it is easily accessible, and illustrations of all stages of volcanic action are found there. There are three Italian volcanic districts—(1) the Roman, in which there is no active vent, but perfect craters and great crater lakes; (2) the Sicilian; and (3) the Neapolitan, both of which are partly terrestrial and partly marine. With regard to the supposed connection of the sea with volcanic action, as a source of water-supply, it is interesting to note that the two regions which still touch the sea are active, whilst the Roman region, which has been separated from it by the advance of the coast-line, is extinct.

FORMATION OF THE VOLCANO.

One specially good instance of the birth of a volcano has been recorded by four eye-witnesses. In September, 1538, Monte Nuovo, a hill 430 feet high and 8,000 feet in circumference, was raised in three days on the shore of the Bay of Naples. There had been earthquakes for two years, which increased in frequency, when a fissure was formed which emitted springs, first of cold and then of boiling water. On Sunday night, September 29th, the earth suddenly burst open, and great quantities of ashes mixed with water were ejected, covering the country for miles round, and the sea retreated for some distance. No lava issued from this cone, which was entirely composed of ashes; and there has been no eruption on the same spot since. Thus is formed the simple volcanic cone.

Passing on to more mature stages of volcanic existence, we will take Vesuvius as an example. In prehistoric times this mountain would have formed a perfect cone, the top of which, being blown away, produced the wide crater-plain which existed up to A.D. 79. Previously there is no record of volcanic activity, but in that year the western side of the old volcano was blown away, and a new cone formed. By this eruption Pompeii and several other towns in the district were destroyed. Since then the volcano has been in constant activity. Vesuvius is divided into several zones. The lower cultivated slope, merging into the plain, is composed of disintegrated volcanic rock, and is very fertile. This extends to 1,500ft. above the sea-level. The Desert Platform, a barren and desolate waste continually invaded by fresh lava streams, reaches from 1,500ft. to 2,500ft. On the eastern side is the ridge of Monte Somma, which half encircles the active vent, and is part of the original cone destroyed by the eruption of A.D. 79. The present cone is three miles in circumference, and 1,500ft. in height above the Desert Platform. The summit alters with every eruption, and smaller secondary cones are formed inside the chief crater.

Etna is a more complex example of the colossal volcano. It is 10,840ft. above sea-level, and there are several zones of vegetation between the base and the desert region. There you see nothing but scoriae, lava, and snow. The great height of this cone causes the hydrostatic pressure in the central pipe to be too great to allow of the lava now reaching the central crater; and by the yielding of the sides, parasitic or daughter cones are formed. At subsequent stages in the existence of a volcanic cone the ground underneath becomes fissured, and an easier vent for the volcanic forces being thus provided, small cones or puys are formed in the plain around the base of the volcano.

THE ERUPTION.

As an example of a great eruption, we may take that of Vesuvius in 1872, in which several adventurous tourists lost their lives. The flow of lava was so profuse that Professor Palmieri wrote—"The cone seemed completely perforated, and lava oozed, as it were, through its whole surface. I cannot better express it than by saying—Vesuvius sweated fire." Terrific discharges took place from the summit, ejecting enormous quantities of steam and ashes, reaching 5,000ft. above the top of the mountain, which were carried slowly along by upper air currents. Darkness was produced over a considerable area, and the rain of ashes devastated the crops and caused great alarm. One lava stream on the western side carried away large portions of two villages, and so rapid was its flow that the villagers were barely able to save their portable

possessions, and some lost everything. The decadence of the eruption was accompanied by a storm of thunder and rain, which brought down the hurtful gases and salts from the great cloud, shrivelling up grass, vines, and trees.

Eruptions are not, however, always so violent as this, and in the case of Stromboli the sequence of events can be watched at close quarters without danger. Stromboli is a volcanic cone near Sicily, which rises out of the Mediterranean to a height of 3,090ft., and has been in constant activity for at least 2,000 years. The crater is in the side of the mountain, and from it clouds of vapour issue continually. The outbursts occur at intervals of from one to twenty minutes, and are unequal in intensity. By care an observer can climb to a point above the crater and watch the eruption. The black slaggy bottom of the crater is traversed by fissures, from which many jets of vapour curl quietly up. From larger apertures bursts of steam take place at intervals and molten rock wells out. In other openings a viscid substance is seen slowly heaving up and down, until a gigantic bubble is formed, which, bursting violently, sets free a great mass of steam, which carries fragments of the molten rock high into the air. Thus in this working model, as it were, of a volcano, we see the essentials of all volcanic eruptions :—1. The existence of apertures communicating with the interior of the globe. 2. The presence of highly-heated matter beneath the surface. 3. A large amount of subterranean water, which by contact with this molten rock becomes suddenly converted into steam. These three conditions explain eruptions alike on the smallest and the largest scale.

PRODUCTS OF ERUPTION.

Many vapours are given off by a volcano, including acid gases, such as chlorine, hydrochloric acid, and sulphuretted hydrogen. In less active stages carbonic acid is emitted in large quantities. Steam, however, is the most important vaporous product of volcanic action, forming 999-1000ths of the whole cloud. It has been calculated that, during an eruption of Etna which lasted one hundred days, the steam emitted each day would, if condensed, have produced four and a half millions of gallons of water. Thus, we cannot be surprised that floods of water play a considerable part in the devastation which accompanies volcanic eruption. These water floods are produced either by the condensation of steam, or by the melting of masses of snow, owing to the rapid rise in temperature, or by the disruption of subterranean reservoirs. An instance of the last was seen in Java in 1817, when a lake of hot, acid water filling a large crater, was suddenly discharged with frightful destruction. Water rushing down the cone collects the volcanic dust and forms a mud lava,

which afterwards consolidates into tuff. It was by such a mud lava that Herculaneum was engulfed in A.D. 79.

Various fragmentary materials are ejected by the force of an eruption. The finest of these forms a light grey powder called ash, though it is not a product of combustion. So fine is this ash that Mr. Whymper estimated that though two millions of tons were ejected in one eruption at Cotopaxi, there would be from 4,000 to 25,000 particles in each grain weight. During an eruption in Nicaragua in 1835, there was darkness over an area of thirty-five miles in radius; the ground twenty-four miles from the mountain was covered ten feet deep, and the ashes fell 700 miles from the centre of eruption. Larger fragments, from the size of a pea to that of a walnut, and great blocks, are often ejected from volcanoes. In Java, in 1772, a valley nine miles long was filled with angular blocks to a depth of 50 feet. Volcanic bombs, which are lumps of lava, rounded by rapid rotation as they fly through the air, are found in almost all sizes.

Lava is molten rock resembling slag. It is white hot at its exit from the crater, but soon becomes a dull red. Lavas differ in liquidility according to the amount of the included steam, and also according to their chemical composition and temperature. Viscous lavas give off very little steam and take on a ropy structure owing to the crinkling of the cooling surface by the continued movement of the lower layers. Liquid lavas give off much steam, are rapid in flow, and form a sharp, cindery surface. Trachytic (siliceous) lavas are usually thick and lumpy; basaltic (basic) lavas form thin, widely extended sheets. The enormous size of some lava streams may be estimated from the fact that the flow from one eruption in Iceland would form a mountain greater than Mont Blanc.

VOLCANIC DECREPITUDE.

Having thus dealt with the mature and vigorous volcano, it remains to enumerate the characteristics of its declining strength. These consist largely of vaporous emanations. A notable instance is that of the Solfatara, a crater in the Phlegræan (Burning) Fields to the north of Naples. It evolves gases and sulphurous fumes, depositing pure sulphur. Its last eruption was in 1198. Geysers (gushers), which are eruptive fountains of hot water and steam, exist in areas of decaying volcanic activity. Sinter cones and terraces are also formed by the emission of hot springs holding silica in solution. At a further stage carbonic acid gas alone is given off, as in the case of the Dog's Grotto near Naples.

Extinct craters are found in many parts of the world, and there are many examples in the Phlegræan Fields. The largest is Astroni, which is one mile in diameter, having in the centre a

boss of trachytic rock which probably is the plug of the old vent. Now the crater is overgrown with oaks and underwood, and is used as a Royal preserve for wild boar and other big game.

DISSECTED VOLCANOES.

The action of atmospheric agencies on extinct volcanic cones gradually lays bare their innermost parts, and reveals many interesting details of structure. There have been in times past several volcanoes in Britain larger than Etna. The Mull volcano, which once was upwards of 12,000ft. in height, is now reduced to a group of hills about 3,000ft. high. In Skye there is the wreck of a similar colossal cone, and Ben Nevis is carved from the inner masses of another such mountain. Arthur's Seat, Snowdon, and Cader Idris are also formed of volcanic rocks.

That volcanic action is not yet entirely spent in the British area is evidenced by hot springs and earthquakes. The hot spring at Bath, for instance, pours forth daily 180,000 gallons of water at 120 degrees Fahrenheit, and it is said that the materials which it has brought to the surface in solution during the last 2,000 years would be sufficient to form a cone as large as Monte Nuovo. Earthquake shocks are also occasionally felt in our country, such as that which did so much damage in Essex and Suffolk a few years ago, showing the existence of pent-up forces beneath the surface.

The successive stages in the existence of a volcano have thus been traced from its earliest commencement in a mere fissure, around which a simple cone was built up, to a colossal volcano such as Etna, with numerous daughter cones. From this period of full maturity we have followed the fiery giant to a state of decrepitude, when he is able to fume and nothing else. Then comes the period of extinction, and as time goes on the cone is broken down by atmospheric denudation until its hidden framework is brought to light, and entering nature's dissecting room we are able to study the anatomy of the volcano, and thus many of the mysteries of its life history are made clear to us.

An interesting discussion followed, in which Messrs. Thrippleton, Jefferson, Bedford, and the President took part, and the thanks of the meeting were unanimously given to the lecturer, and to Mr. Bedford for his management of the lantern. A hearty vote of thanks also was accorded to those who had lent lantern slides, and especially to Mr. Branson for a splendid series of Italian views.

JUNE 18th, 1891.

Mr. CHAS. BROWNRIDGE, F.G.S., the President, in the Chair.

ANNUAL MEETING.

In opening the meeting the President called attention to the number of resignations, which in contrast with previous years appeared high, but this state of things was owing to many members having been retained on the roll after they had left the neighbourhood or ceased to take an active interest in the work of the Association. The activity of the collector, recently appointed by the Council to collect the arrears of subscriptions, had resulted in the discovery that the roll had not accurately represented the strength of the membership for some time past, and had this work been done year by year without allowing arrears to remain outstanding, the yearly totals would have been more correct and the deficiency would not have stood wholly against this year's total.

The Report of the Council was read and approved, on the motion of Mr. Appleby, seconded by Mr. Mitchell.

The Treasurer (Mr. W. H. Gill) presented the Balance Sheet, which shewed a balance in hand.

The President moved the adoption of this Financial Statement which was seconded by Mr. Waite and carried unanimously.

Votes of thanks were then given to the Writers of the Papers read before the Association, and to the Leaders of Excursions. A vote of thanks was also given to Mr. W. Denison Roebuck, F.L.S., for acting as Auditor, and he was unanimously re-elected for next year.

It was proposed and carried: "That this meeting desires to recognise the able assistance which the Hon. Secretary and the Assistant Secretaries have given to the Council during the past year."

Notice was given that Excursions would be taken to places of geological interest during the summer months, and it was hoped that members, during the next Session would give short sketches of geological work done and interesting objects seen during their holidays. It was proposed to set apart an evening for this purpose, to be occupied by several short descriptive papers, with an exhibition of new specimens and geological photographs.

The election of the Officers of the Association for 1891-92 was then proceeded with. The results were as follows:—

President— Mr. CHAS. BROWNRIDGE, F.G.S.

Vice-Presidents—Mr. J. E. BEDFORD, F.G.S.,
Mr. T. W. BELL,
Mr. WILLIAM CHEETHAM,
Mr. C. D. HARDCASTLE,
Mr. B. HOLGATE, F.G.S.

Hon. Treasurer—Mr. W. H. GILL.

Hon. Secretary—Mr. W. LOWER CARTER, M.A., F.G.S.

Hon. Assistant Secretaries—
Mr. E. HAWKESWORTH,
Mr. A. E. NICHOLS.

Members of Council—
Mr. JOHN INGLEBY,
Mr. SAML. JEFFERSON, F.C.S.,
Mr. REUBEN NUNNS,
Mr. EDGAR R. WAITE, F.L.S.

Hon. Librarian—Mr. A. E. NICHOLS.

REPORTS OF FIELD EXCURSIONS.

APRIL 19th, 1890.

EXCURSION TO CASTLEFORD.

Leader, MR. B. HOLGATE, F.G.S.

Hearing that a fossil tree had been exposed in Messrs. Hartley's brick quarry at Whitwood Mere, several members of the Association went to inspect it: Mr. Skinner, of Bank House, Castleford, having been communicated with, met us at the station with a waggonette, drove us to the quarry, and at once conducted us to the fossil in question. The tree was standing vertically where it grew. We had the stem, which was partly visible, still further exposed in an upward direction, and also downward to the stool, which appeared to divide out into roots in the way common to other trees that have been found in the Coal Measures. It was of such friable material that a pocket-knife had to be used for baring the roots, and even then they gave way. A great deal of the woody interior of the tree had evidently decayed, the outer part having turned by long ages of change into coal, which formed a band of separation betwixt the outer mud, which gradually settled round it, and the inner mud which filled up the hollow cavity, making a cast of the middle of the tree. The thickness of wood left must have been more than merely the outer covering, for the cast was found to be coarsely fluted vertically, and it had no scale markings which would lead to its positive identification. It is, however, very probable that it is of Sigillarian type. It measures 6ft. in height, 20in. in diameter at the bottom, and 10in. in diameter at the top. Mr. Nichols, who has photographed so many geological sections in this district, was again present with his camera, as was Mr. Washington Teasdale, who was similarly equipped.

The section where we found the tree is a fine one, and we are tempted to ask where the materials taken out of the hole before can have gone. The cutting embraces some seventy feet of measure in the vertical, with a face some four hundred yards long. To our left we see a seam of coal near the surface, but inclining in a south-easterly direction until, as it dips under the railway (which is right before us and forms the boundary of the quarry), it has reached a depth of some twenty feet.

Immediately beneath are about three feet of fire-clay, and again beneath this, down to the bottom of the quarry, is a face of what the quarrymen call "blue bind." Standing erect, with its top some ten feet below the fire-clay, was the fossil we had come to see. The "blue bind" is a soft rock, soapy to the touch, of a light slate colour where

broken, and contains numerous nodules of clay somewhat hardened up with carbonate of iron, but not containing enough of this substance to be of any practical value. As soon as our leader saw it he pronounced it to contain numerous very delicate fossil plants, ferns, fronds, &c., and as piece after piece was broken, and the various leaves and delicate stems were exposed they told for themselves how the measures had been formed. They were composed of a very fine mud which slowly accumulated in thickness, burying and preserving the most delicate thread-like stems of aquatic and marsh-loving plants. Amongst others was the delicate plant known as asterophylites. Around a plant of this kind, which had a stem less than one-tenth of an inch in diameter, with frills of delicate fan-like leaves round the stem at each of its joints or nodes, the mud had gradually been deposited during the growth of the plant until it enclosed the circlet of leaves about three-quarters of an inch in diameter. Without disturbing them, carbonate of iron had collected and hardened about these leaves, and so the plant has been preserved in its perfect condition through all these bygone ages. The fossil tree we had come to see was similarly gradually interred as it stood, and the inside having decayed and the top broken off, the mud was deposited in the cavity, and so made the cast before us. There was no woody structure present. Many of these irony nodules contain fossils, and one large piece of crystalline carbonate of iron, of a beautiful pinky flesh colour was also found in one of them.

The "blue bind" makes the very best red brick which can be made. It is not so dry as the stony layers sometimes found, nor so subject to melting as the blacker strata. Above this "blue bind" lies the three feet of fire clay. This does not lie in layers, but breaks into irregularly shaped lumps, and running along it in all directions are the rootlets of trees. These rootlets have broken up the soil and destroyed the layers. It is very good fire-clay, and no doubt will soon be more extensively used than it is at the present time. The trees of which these are roots have gone to make the coal seam above it. The seam of coal lying above the fire-clay is about one foot thick. It is known as the Bateson seam, and is used in the process of brick-making on the spot. After examining the quarry, the party were invited by Messrs. Waters and Sweeting to visit the adjoining glass bottle works belonging to Messrs. Breffitt and Co. The visit was the more interesting from the fact that at Glass Houghton (as its name implies) the old dark green bottles were formerly made. The place at that time was most suitable. In the Red Hills behind the village was found the sand, above it the lime necessary for making glass, whilst a little distance below it and in the side of the same hill the coals were obtained for melting the whole. A few years ago the ruins of the old glass works might be seen to the left on entering the village on the way to Pontefract. As we look on the large quantities of bottles made now, not only in Castleford but for some miles around it, we are struck with the advance this industry has made. The coals and the lime are used as before, but, as fashion changed, a bottle of clearer kind was required, and this want has been met by the use of

a more siliceous sand, containing less iron, which is brought in large quantities from the sands at Lynn in Norfolk, and from the French coast about Calais. The colour is made still more clear by means of arsenic, which takes up the iron. The trade has been still further improved by the introduction of the Siemens furnace, and it was interesting to see the mixture of sand and lime and broken glass as it melted and disappeared on being thrown into the sea of molten glass.

This visit to Castleford, although hurriedly arranged, proved most enjoyable and instructive. B. H.

APRIL 26TH, 1890.

EXCURSION TO LAISTERDYKE.

Leader, MR. THOS. TATE, F.G.S.

If we examine the pebbly bed of any river in Yorkshire we shall find that the stones are of different kinds of material, and if we have made ourselves acquainted with the country, we shall be able to tell within a short distance where each of the stones has come from. In Dr. Lewkowitsch's lecture on Ice and Glaciers it was shown that the different kinds of stone, sand, and mud, which had been torn from their parent rocks, were deposited at the foot of the glacier when it melted, and that from this we might trace the course that the glacier had taken. This kind of deposit was brought most clearly before us on this excursion in a section of Messrs. Cliffe's brickyard at Laisterdyke. The leader, Mr. Thos. Tate, F.G.S., described the section as follows:—

The magnificent section exposed presents the typical characteristics of a boulder clay. In a tough unstratified blue matrix are included numerous angular or subangular fragments of grits, gannisters, ironstones, and coal, not resting upon their flat faces with their long axes parallel, as is the case in water-borne sedimentary beds, but pitched in anyhow and lying at all angles in a confused mass. These beds are divisable into two groups, each representing two episodes. The upper group of yellow clay, with white partings, enclosing only local unworn stones, with, when, near the outcrop of the Elland flagstone, above the 450 feet contour line, light-coloured sharp sands superposed; may be accepted as of the age of the upper boulder clays. The top and bottom "lifts" of the lower group possess peculiar features, requiring elucidation. Both portions have a matrix of ground-down carbonaceous shales, enclosing subangular boulders of grits, calliards, nodular ironstones and coal; but the bottom lift is much more tenacious than the top lift, and in the latter lenticular patches and streaks of dark sand and fine gravel, together with large blocks of gritstone of from 10 to 30 cubic feet dimensions, are exposed. The fine-grained ironstone nodules and the coal fragments, are beautifully polished and scratched. These deposits, which will be just outside the Bradford basin, in a depression scooped out of the Elland flagstone, can be followed continuously for five or six furlongs to the Great

Northern Railway cutting under the Leeds and Bradford turnpike road, and may be seen at intervals along that railway as far as Idle, but always above the 400ft. contour. Glacial deposits inside the Bradford basin, although so near, exhibit markedly distinctive characters. The matrix is a tough fine-grained blue clay, which resists the pick or the blast, and has to be removed by a tedious process with the aid of steel harpoons. This clay ("Bowling Tough") when treated with dilute hydrochloric acid effervesces very freely. All the included stones are highly polished and scratched. The largest are found in the bottom of the basin, and are from the nearest parent rock—the Skipton and Thornton blue limestone. Higher up the side of the basin they consist chiefly of the grey crystalline limestone from Settle, while nearer the brim the small fragments of Dent marble and Silurian rocks from Upper Ribblesdale have been brought a still greater distance. These deposits appear never to have passed over the brim, as they have not been found east, south or west outside of the Bradford basin. No limestones whatever are present in Cliffe's pit, nor does the clay matrix effervesce. What then are the parent rocks? Of these materials the most definite for identification are the ironstone nodules. Are these from the Lower Coal Measures? The nodules above the Black Bed contain carbonaceous matter and carbonate of lime, together with iron carbonate—the metallic iron averaging 30 per cent.—and they weather from a bluish-grey to a reddish-grey tint. The nodules in Cliffe's pit contain more silicate of aluminia, less carbonaceous matter, about 6 per cent. of metallic iron, and weather to a chocolate colour. The nodules of the Halifax beds ("Baumpots") enclose marine remains in iron pyrites, while here the included fossils are all plant remains with hardly a trace of ferrous sulphide. The shales too out of which the baumpots are obtained, are vitriolescent, as is usually the case where pyrites is abundant in carbonaceous substances. For as damp air penetrates the shales these crystals are oxydised, producing ferrous sulphate, sulphuric acid with the whole series of basic sulphates, and especially cockscomb pyrites; the final product being the limonite discolouring the numerous "Red Becks" which dot the western and northern outcrop of the Yorkshire coal basin. Now no white pyrites (cockscomb) forms in Messrs Cliffe's clay pit, and as it does not yield any ferric hydrate it is not likely that the Halifax shales have supplied its materials. Whence, then, have these materials been brought? A systematic study of this enormous accumulation of boulders, collected during the past 25 years from this clay, will lead to the conclusion that they present upon the whole an undoubtedly middle grit *facies*. The grits, calliards, and coal may all have been brought from the northern slopes of the River Aire, but no rock west of Silsden—Pendle or Kinderscout grit or limestone—is to be found therein. It is well known that rock-striæ on Rombolds Moor indicate an ice cover at 900 or 1,000 feet. A tongue of ice would be protruded from a glacier located at that height down to Silsden Pass, and possibly may have cut off the rocks to the west. A bed of nodular ironstone occurs in Holden Gill, but it is not the one we seek, and it should be the province

of local societies to identify the parent rocks represented in this pit. How came they here? In the absence of rock-striæ, glaciation, and moraine, we may well doubt that the ice-sheet ever covered this ground. It is far more likely that a neighbouring glacier—probably the North Sea glacier—dammed back the natural drainage flowing towards it, so forming an extra moranic lake beyond the Rumbolds Moor ice-foot, and that these boulders, with their tenacious matrix and lenticular patches of sand atop, were dropped by bergs floating thereon.

Those who had brought hammers with them found plenty of work, and were rewarded with some beautiful specimens of plant remains. Among the most important were two specimens of the terminal buds of plants allied to and not very different in size from the club mosses which many of us have in our greenhouses to-day. On their way to the pit the members inspected a fine exposure of contorted strata, ranging from above the Elland Flagstone to the Crow coal in the railway cutting near Cutler Heights. B. H.

MAY 26TH, 1890.

EXCURSION TO LOWTHORPE,

YORKSHIRE NATURALISTS' UNION.

Leader, REV. E. MAULE COLE, M.A., F.G.S.

At the eighty-fourth meeting of the Y.N.U., the neighbourhood selected for exploration was a little beyond Driffield, including the villages of Lowthorpe, Ruston Parva, and Kilham. A more picturesque country it would be difficult to find. Rich and fertile under cultivation it abounds in natural beauties. The point fixed for the commencement of the excursion was Lowthorpe, and shortly after twelve o'clock about fifty of the members of the Union assembled at the little roadside station. The permission of Mr. W. H. St. Quintin, M.B.O.U., and Mr. John Dickson had been obtained to ramble over their estates, and the various parties conducted by Messrs. Davison, Mortimer and Ross, soon commenced their quest. The extensive woods to the right first claimed the attention of the party, as they had not been explored before. Thence taking the high road for a quarter of a mile, some fields were crossed to Lowthorpe Mill, where there is a beautiful trout stream well-stocked with silvery fish.

The village of Lowthorpe possesses a fine old ivy-covered church, with its monuments and an old cross. The walk was continued through the fields to Bracey Bridge Mill, and here the romantic scenery baffles description and will amply repay a long journey, the woods and bogs, with their hidden treasures of mosses, reeds, and flowers, forming a natural amphitheatre than which few places are more delightful.

Here the geological party diverged, and proceeded along the high road about half-a-mile to view a chalk quarry at Ruston Parva, in which are found sponges, belemnites, and several other fossils of the

chalk; the quarry covers two acres and is nearly eighty feet deep. Standing on the top a delightful view is unfolded to the gaze. On a clear day, Hull, Beverley Minster, Foston, Kilham, Ruston Parva, Lowthorpe, and Harpham Churches, and the ships in Bridlington Bay being observable.

The Rev. E. Maule Cole, M.A., F.G.S., gives an interesting account of the physical geology of this area.

The district forms the borderland between the Wolds on the west, and the lowland on the east, which though not, strictly speaking, part of Holderness, is a continuation of it. A group of dales issuing from the watershed, known as the High Street, unite at Langtoft, and form a valley stretching S.E. to Kilham, which debouches on the plain near Lowthorpe. Here a beautifully clear stream, celebrated for its trout, is met with, which, rising at Beck Head a little to the east of Kilham, forms the most northern feeder of the river Hull. Occasionally, though very seldom in the course of many years, the water forming this beck has been known to burst forth at Henpit Hole, a mile-and-a-half north-west of Kilham. Then the "gypseys" are said to be out. This requires some little explanation. The fact is that the Chalk is very porous, and holds in the interstices of the rock a great deal of water. What is called "the level of saturation" is continually rising and falling according to the rainfall. After prolonged heavy rains, which however seldom occur on the Wolds, the chalk rock is so thoroughly saturated that it can hold no more, and then springs break out at weak points, and rivers, like the bournes in Surrey, are seen running in dry places. In addition to this, it must be remembered that the dip of the Chalk is towards the east here, and that the plain of Holderness is covered with a thick mantle of impervious boulder clay, so that when as much water has been accumulated under it as the underlying Chalk beds will hold, the surplus is bound to find its way out at the edges of the basin, much the same way as a cup will overflow the rim if you pour too much tea into it. Hence the springs, almost ready-made streams, which, in striking contrast to those on the N. and W., appear on the eastern margin of the Wolds.

Geologically, there was not much of interest in the present excursion. The Chalk beds belong to the Upper Chalk without flints, and are fairly fossiliferous. Sponge remains, especially *Ventriculites*, and the pointed *Belemnitella mucronata* were found. At Little Kelk, a little to the east, there are some interesting sand hills similar to many in Holderness, capped with boulder clay, which contain broken marine shells of Arctic type, and consequently are of inter-glacial age In the valley bottom approaching Kilham there is another such sand mound, containing seams of drifted coal, as at Craike Hill, and marine shells, amongst which figures the ubiquitous *Tellina balthica*.

The pedestrians reassembled at five o'clock at the Buck Hotel, Driffield, where, after tea, the usual Sectional Meetings were held.

At the General Meeting Mr. Dobree, of Beverley, occupied the chair. The minutes of the last meeting having been adopted and a number of new members elected, votes of thanks to Mr. St. Quintin and Mr. John Dickson were heartily passed. Mr. Hobkirk, F.L.S., was

then compelled for a moment to throw a gloom over the party by reference to the loss the Union had sustained by the deaths of Mr. S. A. Adamson, F.G.S., and Mr. P. Wrigglesworth, both of whom had been officers of the society. He moved that the Union express its regret at the loss and send a vote of condolence to the families of the deceased gentlemen. The Rev. E. Maule Cole seconded the motion, and Mr. J. W. Davis, who spoke in support of it, drew the attention of those present to the fact that a subscription list had been opened by which it was hoped to raise £250 for the benefit of Mrs. Adamson and her four children. The motion having been agreed to, the reports from the various sections were read, and the proceedings concluded with a vote of thanks to the Chairman.

JUNE 14TH, 1890.

EXCURSION TO BRETTON PARK.

YORKSHIRE NATURALISTS' UNION.

The geologists who joined this excursion of the Yorkshire Naturalists' Union had a very uneventful day, so far as their science was concerned. Beyond a few exposures showing current-bedded sand stones, and the indications given by a pit shaft or two, there was little ocular demonstration of the Middle Coal Measures, over which, according to the syllabus, our route lay. The district investigated was in the neighbourhood of Dewsbury, and included Coxley Valley, Elmsley Woodhouse, and Bretton Park. The general rendezvous was Horbury Station. There were two excursion parties, the first starting at 11 a.m., having the advantage of the presence of Mr. Spencer, of Halifax, whilst Mr. J. W. Davis, F.G.S., of Halifax, accompanied the second party, which left at 1 p.m.

The chief geological feature of the district is the Woolley Edge Rock, with its fine escarpment, but time did not allow us to examine it. The thinner sand stones, which alternate with shales over this area, form gentle slopes covered with fertile soil, and are well wooded. As might be expected, therefore, there were few exposures, and the pit banks seen were either newly hidden by ashes or did not exhibit anything worth noting. Accordingly our hammers rested quietly in our bags, and we enjoyed the rustic beauty of Coxley Valley and Stonecliffe Wood, and the broad undulating scenery of Bretton Park, undisturbed by the temptation to "grub" for fossils. Waggonettes were waiting at Midgley at four o'clock, and the ride to Dewsbury was most enjoyable after the warm afternoon's walk. Opportunity was given *en route* for the party to visit Thornhill Church, with its fine old tower and well-preserved monuments. An excellent tea was provided at the Royal Hotel, Dewsbury, after which the Sectional Meetings of the Union were held. At the General Meeting a short account of the geology of the district was given by Mr. Davis. The geological features of the district are, he said, for the most part hidden

by the surface soil, and the only way in which one could ascertain the geological structure is by an examination of the sections obtained in sinking coal pits. Nevertheless the district is extremely interesting. To the west of Bretton Park the Lower Coal Measures are characterized by thick beds of sandstone and grit, with intermediate shales and thin coal. The strata in the Bretton Park district are the Middle Coal Measures, which embrace all the coal seams and measures above the Silkstone Coal in the West Riding of Yorkshire. More rapid alternations of sandstone and shale replace the thick beds of sandstone which characterize the Lower Coal Measures and the Millstone Grit, and give a much greater variety and picturesqueness to the scenery and a richness to the soil which compensate for the wild magnificence and solitude of the grit-scarped moorlands. The most characteristic bed of the neighbourhood is the Woolley Edge Rock which ranges in a fine escarpment from New Miller Dam in a southerly direction along Woolley Edge, about two miles east of Bretton Park, and is continued southwards in the direction of Barnsley. The sandstone is a coarse thickly-bedded grit about 100 to 120 feet in thickness. Beneath the Woolley Edge Rock are a number of coal seams, the Winter, Beamshaw, Mapplewell, and Barnsley Coals are most important. At West Bretton the Horbury Rock comes to the surface with the Netherton Thick Coal beneath it; whilst further west, a bed of sandstone, which may be seen north and south of the lake, and in a quarry on the road side in the direction of High Hoyland, is superimposed on the Flockton Coals. At Elmley Moor and Clayton the Blocking Coal crops out, which is generally supposed to be the northern equivalent of the Silkstone Coal. The whole of the district is very much dislocated by faults which add considerably to the beauty and variety of the scenery.

A hearty vote of thanks was given to Mr. Wentworth B. Beaumont for giving the Union permission to visit his park, to Messrs. Hobkirk and Lee for their excellent arrangements, and to Messrs. Rushworth, Aiken, and Ruddlestone for their kindness in guiding the various parties.

JUNE 21st, 1890.

EXCURSION TO INGLETON.

Leader, Mr. C. D. HARDCASTLE.

Taking advantage of a Saturday afternoon excursion to the Ingleton and Settle district the members of our Association, together with a strong contingent from the Leeds Co-Operative Educational Society, took a most enjoyable and instructive excursion to Chapel-le-Dale. On the arrival of the train at Ingleton the geologists started along the high road to Skirwith. Just outside the town is a splendid quarry section of the Mountain Limestone on the south side of the Craven Fault. The limestone here is burnt in large quantities for lime, the narrow ravine through which the Doe once flowed being now widened into a valley by the work of a quarryman. About the middle of the limestone section is a lenticular patch of coal and carbonaceous

shale, probably due to an exceptional river-flood which carried mud and vegetable matter far out into the clear waters in which these great coral reefs were forming. Storrs Common, over which we then struck, is spotted with limestone boulders, which have travelled no great distance, and among them were a few boulders corresponding exactly with the Ingleton "granite," which was afterwards seen *in situ*.

The Mountain Limestone of Meal Bank, situate between Broadwood and the church, and that of Storrs Common differs in its general characteristics from that which immediately overlies the Silurian deposits to the north of the Craven Faults. The former is much higher in the series than the latter, and has been dropped to its present position by the faulting. The limestone south of the faults is used only for burning for agricultural purposes and for mortar, and as road stone, and is extensively quarried by the Craven Lime Company, which, from its large oval continuous kiln, turns out on an average 60 tons per day. Meal Bank forms the southern portion of an anticlinal, the upper part of which has been broken up and denuded. The high inclination of the strata forms a marked feature in the face of the quarry. The limestone north of the faults, good sections of which may be seen at Pecca, Thornton Force, God's Bridge, and Skirwith, is harder and more crystalline, and contains, in the shape of pebbles and indurated mud, relics of the older Silurian deposits. It makes an excellent building stone. Thornton Church was built of stone from Pecca, and Ingleton Church from the Skirwith Quarries.

The upper limestone of Storrs Common has been undermined by denuding agencies at various periods, the circulating waters finding lower levels, and leaving the upper portions to be filled up with *débris*. Two caves have been recently opened out, and the *débris* removed to render them available for visitors. We had not time to pay them a visit but our leader's account may be of service to members on some future occasion. The upper cave has been cleared for 36 yards in a direct line, with an average width of about six yards, height varying from 5 to $3\frac{1}{2}$ yards, with occasional places where fissures occur, or the rocks have fallen from 20 ft. to 30 ft. high, the floor being about 40 ft. below the surface. Within this cavé is a passage near the entrance leading to lower regions, and extending a considerable distance, one branch in the direction of Storrs Hall. When the mud is all removed it is supposed that a connection will be made between the upper cave and the lower one, which is entered by the highway side near the hall. It has other ramifications extending towards Fell End. The lower cave goes down, down, down, by several series of as yet rudely cut steps into still lower regions, it is supposed, about 140 ft. below the upper cave. It is narrow, and in some places the rocks approach low enough to compel the visitors to crouch and to endanger the crown of the hat or head unless due care be taken. They are wanting in stalactite formations to make them attractive.

Regaining the road, we soon crossed the northern fault, the position of which is indicated by a dyke, and walked across the outcrop of the Silurian beds until the works of the Ingleton Granite Company were reached. Here a very interesting section is exposed of a quartz-

ose grit, sometimes conglomeratic, intersected by quartz veins, and containing in places fragments of green slate. In the upper part of this band the proportion of slaty fragments greatly increases, and some of the pockets or inclusions are of considerable size. There is much diversity of opinion as to the origin of this band, which is quarried for road-metal. Analysis shows it to be rich in silica, especially the coarser variety. Mr. Stock, Public Analyst for the County of Durham, &c., recommends it for road-metal on account of its low specific gravity, its small capacity for water absorbtion, its freedom from easily oxidisable or soluble constituents, and its great resisting power to wear from blows and abrasion combined, as applied in the Duration Test. This test consists in exposing standard-sized cubes of the stone to prolonged agitation in a special machine, in contact with standard-sized cubes of hardened steel, in the presence of water.

This bed is regarded as a portion of the Green Slates and Porphyries of Sedgwick, the Borrowdale series of the Ordnance Survey, and the Ordovician series of recent authors, which includes the Upper Cambrian of Sedgwick. As the result of upheaval before the Carboniferous Limestone was deposited, the originally horizontal beds are now in a nearly vertical position. The strike of the beds is N.E. and S.W. Two intercalated beds of slate a few feet thick run through the length of the quarry in the same direction. There is a difference of opinion as to the character, composition, and origin of the stone used as road-metal. It has been called a mixture of "tough coarse grit and fine conglomerate" by one authority, "a felspathic trap" by another, and "basalt" by a third. It has also been named "metamorphic gneiss" and "granite." By recent investigators it has been pronounced a pyroclastic rock built up of the denudation products of a metamorphic area, enclosed in a matrix of felspathic ash. The most numerous enclosures are sub-angular fragments of vein quartz and of quartzite, also plates of a fine-grained cleaved slate. Pebbles of lavas, both acidic and basic, compact and vesicular, may also be noted. More or less perfect crystals of orthoclase, microcline, oligoclase, and labradorite occur isolated. The two kinds of rock—the rough and the fine—have the same composition, and differ only in the dimensions of the particles, the finer being more compact and much harder than the coarser variety; both kinds are frequently combined in the same specimen. Assuming the last-mentioned theory to be correct, the beds of slate just alluded to may represent periods of quiescence of the volcanic action.

After explanatory remarks by the leader, the party made for Beezley's farm, some crossing the stepping-stones, whilst others preferred to work their way along the easterly bank of the stream. The glen from Beezley's to Ingleton, though its beauties are comparatively a modern discovery, is now too well known to need description. Suffice it to say that, except for the lack of sunshine, the ravine looked its best. There was a considerable volume of water of the deepest peat-brown hue, which, if it impaired the snowiness of the falls, helped to give variety to the scene. Below we could watch the stream at work deepening its bed, the countless eddies on the surface

telling of rotating mills beneath, forming, by the aid of shingle, pot-hole after pot-hole. Overhead hung a canopy of oak, mountain ash, and hazel, diversified by an occasional holly, fir, or birch; whilst many-hued mosses clothed the rocks in a rich greeny-brown, which contrasted pleasantly with the brighter hues of bilberry and fern on the slopes above.

Here we may briefly summarise the geological features of Chapel-le-Dale. From Ingleton it runs in a north-easterly direction for five or six miles towards Ribble Head. On the north-west it is bounded by the long ridge of Whernside, which rises by steep terraces to a height of 2,414ft. On the south-east the more conical mass of Ingleborough attains almost the same elevation (2,373ft). That the strata which compose these two hills were once continuous across the valley is evidenced by the similarity of the series of beds, both having a thick basement of Mountain Limestone above which come the Yoredale Beds, and each being capped by Millstone Grit. The valley has thus evidently been carved out of part of a pre-existing table-land. As the stream has worn its way downwards, so frost, rain, &c., have eaten back the lofty sides, and during the frequent submergences of our land, the waves have, no doubt, had a part in shaping the cliffs which now rise so precipitously. At the bottom of the massive Mountain Limestone there is a conglomerate, which varies in thickness, in some places being a breccia of limestone fragments, in which lie buried large branching corals, only slightly rolled. The dale rises gently towards the north-east, and the Mountain Limestone dips slightly in the same direction, so that the limestone beds close in, as it were, and near the church pass across the valley. Thus on a geological map the denuded limestone takes the form of the letter U turned upside down (∩), and the grand scars rise aloft, tier over tier, like the battlements of some giant's castle. The river Doe, or Dale Beck, after flowing for some miles between Blea Moor and Whernside, plunges underground near Weathercote, and lower down receives the Ellerbeck which forms the grand cascade which makes the cave famous. After a further underground course it emerges at the point where the limestone beds stretch across the valley. Thence it meanders for two and a half miles through the alluvial flat of the dale, until at Beezley's farm it plunges down in a series of picturesque falls, and runs through a winding ravine or canon, called Baxenghyll Gorge, to Ingleton. The windings of the stream seem largely determined by the divisional planes of the beds through which it has cut its way. For the most part it follows prominent joint planes which run parallel to the axis of the valley, but at other times, with a sudden bend (probably due to the obstruction offered by a band of grit), it turns at right angles along the bedding and cleavage planes, which are nearly vertical. The succession of Silurian beds revealed by this work of denudation consists of a great thickness of green slates interbedded with felsitic grits. In some places the slates show slickenside along joint planes, due to a sideways thrust; and in some of the grit bands beautiful cubes of iron pyrites are developed. Here and there a little rill was seen which evidently had gushed out of the Mountain Limestone

above, for, as it trickled down the bank, it left its burden of carbonate of lime behind, encrusting twigs and roots with a porous crust of calcareous sinter. At the mouth of the valley the strata are broken across by the great dislocations called the Craven Faults. The lines of these faults are marked by mica trap dykes, which also in other cases find their way for a short distance along joint planes. The Coniston Limestone, which, with the exception of a superincumbent bed of contorted calcareous shale, is the uppermost Silurian bed seen in this section, is impure and rubbly, and probably much altered by the faulting and the intrusion of the dykes. Immediately after crossing the line of fault we come to massive Carboniferous Limestone. Further south parallel faults bring down Yoredale shales and Coal Measures, evidencing a total dislocation of thousands of feet.

The following interesting information on the Nomenclature of the Becks was furnished by Mr. Hardcastle.

According to the nomenclature of the Ordnance Survey, the river Greeta is formed by the junction at Ingleton of two streams, viz., the Twis, Greet, or Kingsdale Beck, which flows between Thornton and Twistleton, and the Doe or Dale Beck, from the hamlet of Chapel-le-Dale (the upper portion being simply called Chapel Beck). The confluence occurs about twenty yards north of the viaducts on the London and North-Western Railway.

Some controversy has taken place as to the original names of these streams, some writers contending that the true and original name of the river from Gate Kirk Cave, by Weathercote to the Lune, is the Greeta, and that the stream down Kingsdale has always been regarded as a tributary. This is probably the correct view, notwithstanding other contentions, *e.g.*, that the Kingsdale Beck was the Greeta, and Chapel-le-dale Beck the Doe, Dawe, or Wease; or, again, that the name Greeta only applied to the portion of the stream from Ingleton to the Lune. The fact is, there has been some confusion in the maps of the last century. In Saxton's map, 1577, Speed's, 1610, and Morden's, 1695, the two streams are named respectively Greeta and Kingsdale (spelt Kinesdale by Saxton), but the hamlet now called Chapel-le-Dale, they call by its original name Wisedale Chapel, *i.e.*, probably, Holy Dale Chapel. Bowen, 1750, gives Greeta from Wisedale Chapel, with Daw Beck as tributary. Jeffries, in large map, 1770, does not name the streams, but calls the valleys Kingsdale and Chapel-le-Dale. The Rev. John Hutton, Vicar of Burton-in-Kendal, in "A Tour to the Caves in the Environs of Ingleborough and Settle, in the West Riding of Yorkshire, 1781," second edition, gives Wease, or Greetah, for the eastern branch from Gate-Kirk-Cave by Chapel-le-Dale to Ingleton. Tuke, in his map of Yorkshire, 1787, gives Wease river from Chapel-le-Dale to the border of the county, with Kingsdale Beck as tributary. Greeta is not named. Sir Henry Spelman, in "Villare Anglicanum," 1678, and other earlier topographers, speak of the Chapel in Wisedale, altered by degrees, as shown above, to first Chapel-dale, second, Chapel-in-the-dale, and lastly, as now, Chapel-le-Dale. Greenwood's map, based on Col. Mudge's Ordnance Survey published in 1817, omitting the names of the streams, inserts those of the dales only, as

Kingsdale and Chapel-le-Dale, and from Ingleton to the Lune Greeta river. In the recent Ordnance maps the western stream north of Raven Ray is named Kingsdale, and south of Raven Ray to Ingleton, the Twiss or Greet, while the eastern branch is called Chapel Beck from Weathercote to Dale House, and thence to Ingleton "The Doe or Dale Beck," and forward to the Lune the Greeta. The evidence is in favour of Greeta as the name of the river from Gatekirk or Weathercote to the Lune. The modern guide-books are confusing, and, under the circumstances, it would be well in future to adopt the nomenclature of the Ordnance Survey (although it may not be historically correct), and call the western branch Twiss, and the eastern Doe. Mr. Balderstone, in "Ingleton Byegone and Present," derives the name Wease from Twis by the omission of the initial T; but the dale was called Wease, or Wisedale, long before the name Twis, a contraction of Twistleton, was applied to the other stream.

Before leaving Ingleton a very hearty vote of thanks was passed to Mr. Hardcastle for his genial and able leadership.

JULY 12th, 1890.

EXCURSION TO KILDALE IN CLEVELAND.

YORKSHIRE NATURALISTS' UNION.

The district selected for this excursion was the valley of the Leven, from Kildale to Battersby and Ayton, the moors above, and the Whinstone Dyke at the foot of Roseberry Topping. Although dull the weather was fortunately favourable, no rain falling till about five o'clock, when the field work was over.

The Geological party were under the leadership of Dr. W. Y. Veitch, of Middlesbrough, president of the Cleveland Club, and the Rev. J. T. Hawell, M.A., Vicar of Ingleby-Greenhow. Leaving Kildale Station they first proceeded to examine the peat bed revealed by the railway cutting, but no satisfactory exposure was seen. The horns of the Red-deer (Cervus elaphus) and Reindeer (C. tarandus) have been found in this bed. Similar deposits occur in the vicinity of Middlesbrough and of Hartlepool.

An investigation was next made of a large deposit of rubbish thrown out near the site of the old ironstone workings. This *débris* was found to be much weathered, as might be expected from the length of time it had been exposed to the atmosphere, and many characteristic fossils of the mid-liassic zone of Am. spinatus were found, including Am. spinatus, Pecten æquivalvis, Monotis inæquivalvis, Lima acuticosta, Rhynchonella tetrahedra, Terebratula punctata, Belemnites breviformis, Ostrea submargaritacea, and Chordophyllites cicatricosus. Many fragments of fossil wood were also observed.

The Cleveland Main Seam of Liassic ironstone, which at Upleatham, only a few miles away, has an undivided thickness of 13ft., here has dwindled down to 5ft. 4in., and even this includes an interbedded band of shale measuring about 1ft. 3in.

Proceeding thence through Kildale Wood lower beds of the Middle Lias were seen. The hardness of the Margaritatus bed has given rise to a small waterfall. Ascending the steep hillside to Easby Moor a rubbish heap of Upper Lias (Alum shales) was examined, and a few small bivalves found. The cap of the hill is formed of the sandstone of the Lower Estuarine Series which has been quarried for wall-building. A little higher up the top was reached on which Captain Cook's monument stands, and from thence an extensive and geologically instructive view was obtained.

To the west stretched out a wide and fertile plain sparsely dotted with hamlets and farm buildings, whilst the red-tiled roofs of Ayton below gave a pleasing variety to the landscape. To the south west a faint mist indicated Darlington, whilst to north and north-west the rolling clouds of smoke showed plainly the proximity of Middlesbrough and Stockton. To the south and east were the bold outlines of the Cleveland Hills, while immediately to the north the conical outine of Roseberry Topping, capped by the same Oolitic sandstone as Easby Moor, was a prominent object. A well-defined ridge was seen to run round all the hills at the level of the Margaritatus zone, whilst above another prominent escarpment was formed by the Estuarine beds. At a lower elevation, a conspicuously marked band of rubbish mounds, indicated the position of the zone of Am. serpentinus which has been extensively mined for jet. Here and there on the lower ground might be discerned hummocks of sand and gravel, due to the Middle Glacial epoch.

On the northern side of Easby Moor was an extensive exposure of the Alum shales, in the upper part of which were thin lenticular bands of nodular grit of small extent. Passing through the hamlet of Langbargh we began the ascent towards Roseberry Topping, passing through Airey Holm where Captain Cook once lived in his father's house. This place has been identified, the Rev. J. T. Hawell told us, with the ancient Hergum, which in turn took its name from the *horg* or blot-sten, the sacrificial open-air altar made use of in the worship of Odin. The old name of Roseberry Topping was Odinsberg, but how this name came to be superseded by the modern title, and what the first half of Roseberry signifies are questions which historians and philologists have not yet satisfactorily solved.

At the foot of Roseberry Topping some rubbish heaps of Middle Lias were hammered over and many characteristic fossils obtained, the only one additional to those obtained near Kildale was Lima hermanni. Here also were seen relics of glacial action in sections of large mounds of irregularly bedded sand and gravel beds, and heaps of boulders, some of which had travelled from the Cheviots. Here an interesting discussion took place on the question of the formation of the valleys and hill contours. Dr. Veitch attributed them principally to ice action, while several members of the party were of opinion that the primary cause was water-denudation (river and sea), and that this action had been further accentuated by ice action. As we returned to Great Ayton Station a visit was paid to the Whinstone quarries in its vicinity. This stone is extensively used for road-making. It has

been described as "a bluish-grey augite-andesite, consisting of a ground mass apparently made up of augitic and felsitic matter, with small crystals of felspar and augite. Scattered through this are glassy crystals of triclinic felspar of much larger size, distinctly visible to the eye, which give the rock a distinctive character by which it can be easily recognised." The Cleveland Dyke at the base of Roseberry Topping is 80 ft. thick, but only 20 ft. thick at its outcrop 350 feet above. It extends from near Whitby to the neighbourhood of Armathwaite in Cumberland.

The party then proceeded by train to Middlesbrough where tea was provided at the Railway Station Dining Room. Afterwards the usual meetings were held when the geological reports were presented by Mr. W. L. Carter, M.A., F.G.S., and the Rev. J. T. Hawell, M.A.

Hearty votes of thanks were presented to Lady De L'Isle and Dudley, Captain R. Bell Turton, and Mr. James Emerson for permission to visit their estates, to the gentlemen who had conducted the excursion, and to Dr. Veitch for presiding. In reply the Chairman said that he hoped they would carry away from that smoky district a better impression than generally prevailed concerning Middlesbrough and its surroundings. The visitors left Middlesbrough by the 7.28 train for their respective destinations.

JULY 19TH, 1890.

EXCURSION TO ALMES CLIFF CRAG.

Leader, Mr. WM. CHEETHAM.

The local excursions are always very popular with the members of our Association, and a goodly number, accompanied by several ladies, took the opportunity of visiting this famous crag under such favourable circumstances. The weather was graciously disposed towards us, the heavy clouds which had been threatening a continuance of rain cleared off about noon, and a glorious afternoon was enjoyed. The party proceeded by the 2.40 train to Weeton Station, and walked thence through the fields to the Crag, where they were met by a party from Harrogate. After the celebrated rock had been inspected, and the grand, extensive view therefrom enjoyed, the company gathered together under the cliff to hear an address from our veteran leader on "The Geological Anatomy of Wharfedale," with an account of some of the formations visible from the Cliff within a radius of 30 miles.

The Lecturer commenced by a feeling reference to the late Mr. S. A. Adamson, F.G.S., whose loss the Association so much deplores, and spoke of his delight in getting away from the lecture-room to study in what he called Nature's class-room, ventilated and swept by the winds of heaven. Mr. Cheetham mentioned that the last letter written by our late Secretary was one thanking him for agreeing to conduct an excursion to Almes Cliff Crag. Mr. Cheetham then proceeded with his geological remarks. Geology, he said, teaches us what the world we inhabit is, and how it came to be as we find it. Field work is a necessary part of our science curriculum. No collection

of fossils, however vast, can adequately represent geology, any more than the Egyptian mummy in the Leeds Philosophical Hall can be accepted as representing the living grandeur and magnificence of the courts of the Pharaohs. The geological features around, which are now to be described, have occupied vast periods of time in their production, extending, as they do, from the Mountain Limestone to the Chalk. But in studying geology we must remember that there is an eternity in the past, as well as an eternity in the future. Good instances were pointed out, in the district to be seen from the Crag, of escarpments, or abrupt cliff-like terminations of hard strata, and dip slopes, or the gradual slopes due to the natural inclination of the beds forming the mass of the hill. Reference was also made to the faulting of the district, the strata having been dislocated in all directions, as was evidenced by the geological map, by the earth movements which had raised the rocks from their original horizontal position. The whole course of the Wharfe is 52 miles as the crow flies, but to follow the windings of the river 80 would have to be traversed. From Harewood Bridge it is 17 miles to the point near Cawood where it falls into the Ouse, and 35 miles to its source under Cam Fell. At Harewood Bridge the river is 98ft. above sea-level, but at Cam Houses it rises in grit beds at a height of 1,273ft. After flowing for three miles through the beautiful defile of Outershaw, the stream unites at Beckermond with the Greenfield Beck, which flows along the south side of Cam Fell, and the two uniting form the Wharfe. Down to Buckden it is a mountain stream tumbling over the rocks in a succession of cataracts which are very fine when the river is flooded. Below Kettlewell the limestone escarpments on either hand are remarkable, showing a regular series of terraces one above another up the mountain sides. Near Kilnsey the Wharfe is joined by the river Skirfare, which is formed by the becks that rise in the deep valleys east of Cush Knott and Penyghent, the two streams forming a good river. Near Grassington there are a number of cascades, which look quite white by moonlight, and hence get their name, Ghaistrills (ghost rills). Below Burnsall the limestone dips beneath the Yoredale rocks, and the stream has cut deeply into the underlying Millstone Grit in the deep glen of Barden, and at the Strid carves its way through the Kinderscout Grit (450ft. above sea-level). Mr. Cheetham here gave it as his opinion that the rock at the Strid was identical with that which caps Almes Cliff, though some have placed the latter among the Yoredale beds. Mr. J. W. Davis, F.G.S., also calls the Almes Cliff rock Kinderscout Grit. The course of the Wharfe now to be described was seen from our natural observatory, and the lecturer alluded to the varied outlines of the hills, and the beautiful contrasts of light and shade which Turner delighted to portray. He pointed out that these natural beauties were largely due to the geological structure of the district, the varied outline being due to the dip of the strata, the faulting, and the material, whether hard rock or shale, of which the hills and dales are composed. Taking a survey of the surrounding country, it was pointed out that we were in the midst of the grits and shales of the Carboniferous series. Under the Coal Measures of the

Leeds district come the Millstone Grit beds which crop out to the north and east, and are in this area 3,000ft. thick. Below them come the Yoredale beds which are exposed in the Harrogate anticlinal. The lowest bed of the Millstone series is the Kinderscout grit or conglomerate, which derives its name from Kinderscout in the High Peak where it forms an elevated table-land. In Wharfedale it is well exposed at the Strid, forms, as has been said, the bold escarpment of Almes Cliff, and is well seen in the Pannal quarries. Above the Kinderscouts comes a considerable thickness of shale and then the Third Grits which form the well-known rocks of Plumpton and Brimham, the Cow and Calf rocks at Ilkley, Otley Chevin, and Harewood Park. At the top of the series is the Rough Rock which immediately underlies the Coal Measures, and is seen at Horsforth, Calverley, and Baildon. To the east of Almes Cliff the Carboniferous beds are unconformably overlaid by Secondary rocks, the lowest of which is the Magnesian Limestone, over which the Wharfe runs by Wetherby and Tadcaster, and then for three or four miles over New Red Sandstone to its junction with the Ouse. The central position of Almes Cliff was then alluded to; Hornsea being 58 miles due east, and Fleetwood 52 miles due west. Kirkby Overblow, three miles to the east, is exactly central betwixt sea and sea. In conclusion, Mr. Cheetham spoke of the unrivalled position of the Crag for viewing the country during the hunting season, calling it "the grandest grand-stand in the kingdom."

A hearty vote of thanks to our lecturer for his able and interesting address was moved by Mr. J. E. Bedford, F.G.S., and seconded by Mr. Redmayne. A very pleasant sequel to this intellectual feast was the excellent "pic-nic" tea provided by the ladies in the open air, which served to complete the enjoyment of a really grand afternoon. Several views of the Crag were taken by Mr. A. E. Nichols, and in addition an "after-the-battle" scene, showing the tea table subsequent to our vigorous attack. Many of the members returned to Leeds by the 7.17 train, while the rest of the party remained to see a fine sunset and enjoy a little longer the fresh, exhilarating air, reaching the New Station about ten o'clock.

JULY 30TH, 1890.

EXCURSION TO FARNLEY.

On Wednesday, July 30th, the members of the Leeds Geological Association, by the kind permission of Mr. E. Matheson, managing director, enjoyed a most interesting and instructive evening at the extensive works of the Farnley Iron Co. (Limited). Taking the 6.30 train to Wortley and Farnley Station, the geologists walked to the ironworks, where they were met by Mr. Hepworth, forge manager, Mr. Stock, blast-furnace manager, and Mr. Sheard, colliery manager, who kindly undertook to act as guides over their various departments. As an introduction Mr. Sheard led the party to a small working in the Black Bed coal, called Birks day-hole. The tramway leading to this

day-hole was almost buried in liquid mud, the avoidance of which required a considerable amount of dexterity on the part of the enterprising few who risked their boots and hats to see a pretty section of a fault near the entrance. This afforded the leader an opportunity of explaining the section of the beds, which here furnish not only the excellent ironstone, but the coal for its reduction, and also the clay, which is made into splendid glazed and fire bricks, gas retorts, and sanitary tubes. The seam worked here is the Black Bed coal, which consists of 18 inches of bright coal, with six inches of stone or cannel coal at its base. At a depth of about 40 feet below this coal-seam comes the Better Bed coal, which produces a very superior quality of coke, remarkably free from sulphur. The fire-clay mentioned above is the seatstone of the Better Bed seam. Above the Black Bed coal thin bands of ironstone nodules alternate with thin shales, on the top of which comes a micaceous sandstone rock. At the mouth of the day-hole was a heap of ironstone nodules, which were inspected by the members. These nodules are flattened oval cakes of a black or brown colour, and when broken show a hard compact structure, often with enclosures of organic matter. Their composition is largely carbonate of iron, mixed with clay and bituminous or carbonaceous matter. They appear to have been formed in the shale, subsequently to its deposition, by the action of infiltrating water in the presence of decaying organic matter. Very often the ironstone has accumulated round some fern, shell, or fish-bone, which has served as a centre of chemical attraction for the irony matter distributed through the clay. Some of these concretions are compact and contain little carbonate of lime, whereas in other bands they are cracked, probably owing to contraction on drying, and the spaces have subsequently been filled with calcite (carbonate of lime) by the infiltration of water containing that salt in solution.

Later in the evening Mr. Sheard gave us the opportunity of inspecting the plan and section of the pit workings, which showed how numerous the faults were, some causing a dislocation of the beds of thirty or forty yards, whilst in other cases the throw was only a few feet. At one place there is an interesting series of step-like faults, some upwards, some downwards, testifying to the amount of bending and cracking which the rocks have suffered in ancient times. The expense and annoyance which are caused to the coal-workers by these faults was intimated by our leader's remark that the proper name for a fault is "a trouble." In one place the section showed an interesting instance of contemporaneous erosion, telling us of the action of denuding as well as depositing agencies in Coal Measure times. The shaly ironstone beds which overlie the coal were found for some distance to disappear, and then re-appeared again with their former thickness, the gap between being filled with the sand rock. This told a tale of a great swampy forest area depressed beneath the waters of a shallow sea, and covered up by irony clay. After a time the area was again raised for a short time into a mud flat, over which a river ran with sluggish current, excavating a channel for its waters. But ere it had been able to wash away more than the soft upper mud

deposits the land was again depressed, and a more rapid river current brought down sand and mica from some granitic range, depositing them in thin layers, the sand in the times of normal river-flood and the silvery mica scales sinking down in layers whenever the flow of the stream was checked, this sandy deposit not only covering up the shale, but also filling up the trench cut down to the surface of the coal-bed by the pre-existing river. Arrangements had been made for an inspection of the Farnley day-hole, but the fascinations of the blast furnace and the forge kept the members entranced, to the neglect of their proper geological pursuits, until darkness came upon them and disclosed the full weirdness of the scene. Regret at this partial failure in devotion to our mistress-science was lessened by a hint that if we had gone into the recesses of the mine, we should probably have returned to moonlight covered by a layer of the crust of the earth to the study of which our Association dedicates its existence.

Having thus had an introduction to the raw material, the next stage was the blast furnace, to which those who could resist the attractive glow of the puddlers' fires were conducted by Mr. Stock, whose indefatigable efforts to make each point in his department clear to us were much appreciated. First we were taken to inspect the interior of one of the furnaces, which was being re-lined with large fire-bricks, manufactured on the premises. In building, a space of three inches is left between the inner fire-bricks and the outer shell of the furnace, this space being packed with sand to allow for expansion. The lower part, or hearth, was four feet in diameter at the level of the blast pipes or twyers (tuyères), whilst at the boshes, or widest expansion of the body of the furnace, the diameter is 12 feet. The twyers, three in number, are conical tubes of cast iron, with double walls, between which cold water is kept in constant circulation to preserve them from being melted. They are supplied with cold-blast air (*i.e.*, at the ordinary temperature) from a large iron receiver into which the air is forced by a pumping cylinder worked by a powerful steam engine, which creates a pressure of 2½lb. per square inch. The dam-plate, which confines the metal within the hearth until the smelting process is completed, is fixed five inches below the level of the twyers, and is kept from melting by being traversed by pipes through which a stream of water is kept constantly flowing. Over this plate the slag, or refuse, pours in a white hot rill, which is received into iron boxes kept cool by a constant flow of water between an inner and an outer shell. The slag as it cools forms large stony blocks; the interior, which cools most slowly, takes on a rough crystalline structure, is hard and tough, and makes good road metal. The quickly cooled outer layers are glassy, and vesicular from the escaping gases. They show the most beautiful streaked structure, coloured all tints of purple and green by the included metallic salts. In some parts of the country this beautiful stone-glass is utilised for the production of handsome pottery ware. Under the action of the weather this external portion breaks up readily into fragments of flinty hardness with a knife-like edge. As it issues from the furnace the slag can be easily drawn out into fine filaments of an astonishing length.

Ascending a long flight of steps we then gained the charging-platform at the top of the furnace, and gazed at the mass of purplish flame which rushed from the chimney mouth. On this stage the calcination or roasting of the ore, is carried on in an iron kiln open to the air top and bottom. The men are protected from the rain by a large umbrella-like shed, whilst special shields keep off the prevailing winds, which, in this exposed spot, must blow with chill severity the long winter through. In this kiln the ironstone is slowly roasted in the presence of air. The only fuel required is a small quantity of the refuse coke, on account of the carbonaceous matter which the Black Band ore contains. In this preliminary process the ironstone loses one-third in weight, owing to the expulsion of water and carbonic acid, and the combustion of the carbonaceous matter. It is also rendered more porous by this process, and hence can be more easily smelted. If sulphur be present it unites with the oxygen of the air to form sulphurous acid gas and escapes. This calcined ore, which consists essentially of oxide of iron mixed with clay, has now to be smelted in order that the oxide may be converted into metallic iron, and the earthy matter removed. To effect this alteration the ore is mixed with coke and limestone in proportion of $10\frac{1}{2}$ cwt. of coke, and 4 cwt. of limestone, to 15 cwt. of calcined ironstone—this forms one charge. During the smelting process the oxygen is removed from the iron ore, and the metal sinks down to the hearth, the lime uniting with the clay to form a fusible slag, which, being much lighter than the metal, swims on the top and flows over the dam-plate. The coke used is produced from the Better Bed coal, which is remarkably free from sulphur; the limestone comes from the Ribblesdale district. The high temperature required for these changes is created by the blast. Ninety-nine per cent. of the blast furnaces in the United Kingdom are worked with a hot-blast, the air being heated before it enters the twyers, and thus a great saving in fuel is obtained. At Farnley, as at Low Moor and Bowling, cold-blast is used, and though the quantity produced is only one half that turned out of a hot-blast furnace, the pig-iron is of a very superior quality, and specially suitable for steam-engine cylinders, chilled rolls, and similar purposes, where strong, tough, close-grain castings are required. The standard test bars endure 32 to 34 cwt., as against 25 to 28 cwt., which is usual for hot-blast iron.

The pig iron is run from the furnace into moulds, each pig being marked with a brand. The best iron comes off first. In the yard thousands of tons of iron are kept stacked in heaps, each quality being separate from the rest. Instead of being taken direct to the puddling furnaces, as is usual, the Farnley iron is re-melted in open fires and boiled for some time, then cast into cakes or slabs, a considerable quantity of dross or inferior iron being eliminated. The refined iron is then puddled, first becoming fluid, but as the carbon is abstracted by combination with the oxygen of the air, the iron becomes pasty. The important chemical change from cast-iron to wrought-iron has now taken place, and by hammering and rolling it gains the fibre necessary to produce the high-quality material known as Best York-

shire iron. This iron is specially suitable for boiler plates and for all purposes where flanging or other severe treatment has to be endured. Bars of the same excellent metal are used for the hooks and draw-links of locomotives and railway carriages, for the suspending gear of mining cages, and similar places specially liable to percussion and sudden strain. Very interesting examples of this tenacity were on view in the yard, some boiler plates which had collapsed owing to over-heating being curved in the most curious fashion without any flaw. Large bars were shown which had been bent double without the sign of a fracture. Other bars and plates, bent and twisted cold gave evidence of the extreme toughness of the iron.

After admiring the various processes to be seen in the Forge, under the able guidance of Mr. Hepworth and Mr. James Walker, we were shown the splendid machinery which produces the corrugated flues so much used for high-pressure boilers. The speciality of the Farnley flue is its spiral corrugation, which is claimed to have an advantage over the circular corrugation in promoting combustion by a freer circulation of the flame. Very interesting were the facts elicited about the influence of the weather on the manufacture of iron. Outside the window of the furnace manager's office is a wet and dry bulb hygrometer, which needs careful study day by day, so that the furnace-charge may be varied to suit the atmospheric conditions. Mr. Dawson, the Low Moor ironmaster, used to say, "There's nothing like dry frost for iron making," and so it would seem, for $10\frac{1}{2}$ cwt. of coke will smelt 17 cwt. of ironstone during a hard frost, whereas in June or July the amount is reduced to 15 cwt. An instance of putting two and two together and making five of them was given in an amusing story of the Low Moor ironworker, who, as usual, being paid by the weight of metal obtained, had a serious reduction in his wages each summer. He noticed that this generally occurred when beans were in flower, and one day, returning home with only a few shillings in his pocket, declared he would "rive up" all the beans in the place, for they spoiled the iron-making!

Before starting homewards an informal meeting was held in the forge manager's office, when Mr. Carter proposed and Mr. Gill seconded a very hearty vote of thanks to Mr. Matheson for his permission, so readily accorded, to visit the Farnley Works. Also to Messrs. Hepworth, Sheard, and Stock for the generous and genial way in which they had placed their time and knowledge at the service of the members. This was supported by Mr. Howgate, who made special mention of the numerous specimens which the members were enabled to take away, and carried with acclamation. The moon shone brightly as we separated, some for train, some for tram, and others to foot it homewards, all bearing testimony to the pleasure and profit derived from the excursion.

AUGUST 2ND TO 4TH, 1890.

EXCURSION TO UPPER SWALEDALE.

YORKSHIRE NATURALISTS' UNION.

Leader, Mr. J. G. GOODCHILD, F.G.S., M.B.O.U.

Bank Holiday in the little-known district of Upper Swaledale will long be remembered by those who were fortunate enough to be able to be present, as one of the most pleasant, interesting, and instructive excursions that the members of the Union have taken.

With lovely weather, a new country, and a guide whose knowledge it would be difficult to beat, the case could hardly have been otherwise. Askrigg, a charming little village a few miles from Hawes, was fixed upon as the rendezvous, and at the appointed hour members from Richmond, Middlesbrough, Saltburn, Skipton, Malton, Harrogate, Leeds, and several other places, met together and were joined by Mr. Goodchild, F.G.S., the curator of the geological section of the Edinburgh Museum, who had kindly volunteered his services as guide. That these were warmly welcomed may be easily guessed, as Mr. Goodchild has spent a good portion of his life in making a survey of the district for the Government, and may be said to know almost every inch of the ground. No time was lost in making a start, and the party moved off in the direction of the village of Muker, distant six miles across the moors. The first place of interest reached was the Oxnop Pass, through which flows a narrow stream, in which is found a peculiarly light-coloured species of trout. On the way Mr. Goodchild pointed out the various faults and stratifications, speaking of their peculiarities and points of interest in a chatty and entertaining manner.

In his description he stated that Upper Swaledale is situated in the northern portion of the great upland tract lying on the eastern side of the angle formed by the conjoined Craven Fault, and the Barbon—Kirkby-Stephen branch of the Pennine Fault. The general summit level of the *massif* is now more than 2,300 feet above the sea, from which elevation the surface declines in one direction towards the valley of the Tees, and in another direction towards the Vale of York. The western boundary of Swaledale coincides with the central watershed of northern England, and from this, towards the west, the fell side descends rapidly towards the fertile lowlands of north-east Westmorland.

Swaledale consists exclusively of Carboniferous rocks, which are gently inclined, on the whole, towards the north-east, although faults and local disturbances of the strata combine to render this larger feature somewhat obscure. The strata are mostly the Yoredale rocks, which form the greater part of the more striking natural features. These rocks consist of alternations of beds of marine limestone, sandstone, shale, coal, and, near their higher portion, of peculiar siliceous beds, now proved to be of organic origin. The general thickness of the Yoredale rocks is about 1,800 feet. Below the Yoredale rock comes the Mountain Limestone, which, well seen under Ingleborough,

is here only represented at the surface by its uppermost beds. The Yoredale rocks are surmounted by the remnants of the Millstone Grit, which are left as cappings on the summits of the higher Fells. The Swale and its tributary streams have sunk deep valleys into the old massif—in some places nearly two thousand feet below the general level of the summit-plateau. The varied hardness or durability of the component strata has given rise to a fine series of waterfalls, scars, and picturesque fell-sides, whose beauty is finely set off by the wild nature of the moory uplands adjoining.

The route, commencing upon the upper beds of the Mountain Limestone at Askrigg, thence lay over the whole thickness of the Yoredale rocks, and traversed the base of the Millstone Grit at the watershed between Wensleydale and Swaledale. From this point the Yoredales were again traversed in reverse order; and the route from Gunnerside up the dale lay chiefly along a narrow strip of Mountain Limestone, corresponding to the beds seen on starting.

The fine scenery around Keld, Kisdon, &c., is chiefly formed by the Yoredale rocks; but the numerous faults and local variations of dip bring in patches of Millstone Grit at intervals. The watershed at the head of the dale consists chiefly of Millstone Grit, which forms fine mural precipices on the Westmorland side.

Many of the Yoredale and Mountain Limestone beds are fossiliferous, and the members collected good specimens.

At Muker the party were welcomed by the Rev. R. V. Taylor, B.A., Vicar of Melbecks; the Rev. W. Crombie, of Keld; Mr. Fawcett, of Thwaite; Mr. R. Barnes, of Saltburn; and Mr. Tinkler, of Arkengarthdale. Sunday was observed almost entirely as a day of rest, the only visit paid being to what is known in the neighbourhood as Summergill Kirk, around which are to be seen some extraordinary dislocations of the strata. On Monday the annual meeting was held in the Institute at Muker, which had been kindly placed at the disposal of the members, who were cordially welcomed by the Rev. Mr. Harrison. The Rev. R. V. Taylor occupied the chair, and the first business was the election of a secretary of the Geological Section in the place of the late Mr. Adamson. Mr. Horne, F.G.S., whose local knowledge was only second in its value during the excursion to that of Mr. Goodchild, referred in regretful terms to the severe loss the society had sustained by the death of Mr. Adamson, and eventually Mr. Carter, secretary of the Leeds Geological Association, was appointed to fill the vacancy. Votes of thanks were accorded to the officers, and to Captain Lyell (the Lord of the Manor) and Mr. Jas. Alderson, over whose estates the members had received permission to wander. The strictly business part of the programme then came to an end, and the work of exploration was resumed.

The route again lay across the outcrop of the Yoredale rocks, and on the Wensleydale side it passed near the section taken by Professor John Phillips as the type section of the Yoredale rocks. The highest thick limestone of the series, the main or Twelve Fathom limestone forms the bed through which surface waters have eaten out the remarkable swallow holes known as the Buttertubs. Everybody's

curiosity had been aroused as to these unique natural formations, the Buttertubs Pass being one of the great attractions of the excursion. During the ascent, the geological features were pointed out by Mr. Goodchild, who said that it was now an accepted theory among scientists that the existence of the hills was due to a process of denudation, and that where they now stood was once an undulating plain. He also drew attention to the indications of the glacial action in rounding the angles of the hills, and explained in a very lucid manner the curious phenomena of the isolated hill called Kisdon, on each side of which there are evidences that the river once ran, the dry channel being plain to see. On the beds of limestone close by may be seen the hollows popularly known as "Swallow Holes," in which the water disappears, and its subsequent course is lost. These are really the commencement of the peculiar fissures called the "Buttertubs," which vary in diameter from a few inches to 25 or 30 feet, and run through the main limestone to a depth of 60 or 70 feet, their sides being most beautifully carved and fluted by the action of the water, almost as if the work had been done by hand. The powerful influence of the water on the stone is supposed to be due to the fact that gathering, as it does, on the Millstone Grit, it is free from lime, and well charged with carbonic acid gas, and this weak solution of carbonic acid, when it passes through the limestone, dissolves and carries it away. Considering that these Buttertubs are without their like in the country, it is little wonder that the members felt and expressed great regret at finding that the top of one of them had been broken away, and the stone removed for road repairing purposes, and it is to be hoped that the authorities will see their way quickly to put a stop to the practice. On leaving these marvellous works of nature, after some of the members had secured specimens of the fluted rock, the party went on to examine the rugged beauties of Hardraw Foss, where the stream falls into the valley below from a height of 120 feet. Here the hand of man has been at work, and the place abounds in charming nooks and rural walks; while the trees laden with flowers, berries and nuts afforded grateful shelter from the hot sun. A short halt was made, and then the members pushed on to Hawes, where tea was waiting, and to this the weary pedestrians did ample justice. This was the point for the parting of the ways, and, after the usual farewells, the party sought the railway station, and dispersed for their several homes.

AUGUST 23rd, 1890.

EXCURSION TO CALVERLEY,

Leader, MR. WM. CHEETHAM.

The programme of this excursion to Calverley embraced visits to the old church, the quarries, woods, and hanging-stone. Taking the train from the Midland Station to Calverley, the party walked thence up the hill to the Church of St. Wilfred, where they were met by the

Vicar, the Rev. J. W. Hatton, Messrs. Margerison, Gray, and Thornton. The visitors were shown over the church by the Vicar, and much interesting information about its architecture and history was furnished by Mr. Margerison. The oldest part of the present church appears to be the nave, which dates from 1156, and an old Norman window is seen blocked up in the wall. Subsequently the aisles were built and the clerestory raised. There is evidence of the existence of a prior Saxon structure, and the name of the church is sure proof of its Saxon origin. When the church was restored a number of old Saxon tombstones were found, some having been used as window-sills, whilst the smaller ones were built into the wall. The tower arch at the west end of the nave bends over to the north, and has a very peculiar, lop-sided appearance. A similar irregularity is found in the west window, and several of the other arches are far from symmetrical in their curvature. The tower walls also are not in line with the rest of the church. These peculiarities are attributed by most authorities to careless workmanship, and not to the mysterious symbolism which the vivid imagination often discovers in such abnormal shapes. The church appears to have been in ruins after Bannockburn, and it is probable that it was burnt down during the incursions of the Scots subsequent to that notable victory. The Roundheads occupied Calverley during the Civil War, Cromwell at one time being there with 120 men. The probability is that the church was used by the iconoclastic soldiery to supply the lack of stabling accommodation in the village. The only evidence as to the damage done to the edifice during these wars is the record of a considerable expenditure by the churchwardens immediately after the Restoration. On the south side of the chancel, which is not approached by a step, but is on the same level as the rest of the church, there is a leper window, the bars of which existed in the memory of some present. Opposite, on the north side, is the Calverley Chapel. In this a mass of plaster was found, at the restoration of the church, enclosing human bones, which were supposed to be the remains of Walter Calverley of "The Yorkshire Tragedy" fame, and who is reported to have been secretly buried at Calverley. The east window contains some rare old glass from the chapel in Calverley old Hall. The reredos, the gift of Mr. Gray, is a fine copy of Leonardo da Vinci's masterpiece "The Last Supper," splendidly carved in solid oak. Underneath it is a fine Elizabethan communion table, whose ancient and handsome carved legs are now hidden by a modern embroidered altar-cloth.

Leaving the church, the party proceeded through Calverley Woods to the hanging-stone, from which a really magnificent view over Airedale is obtained—a companion picture to that of Wharfedale from Almias Cliff. The hanging-stone is a mass of compact, coarse grit, 350ft. above sea-level, which stands out prominently from the general line of the Rough Rock escarpment. It is underlaid by a thin bed of finer sandstone, which divides easily along its current-bedded layers, and so yields to denuding agencies more easily than the compact rock above. Ultimately this eroding action will cause the projecting mass to topple over and tumble down on to the talus slope below.

Very interesting was the discovery, made by Mr. Thornton, that the hanging-stone is slicken-sided, pointing to movements causing great friction along joint faces in times long remote. One peculiarity of the Rough Rock is the way it hardens by exposure to the weather. The stone of Kirkstall Abbey witnesses to this durability. When York Castle was building the contractor agreed to supply Bramley Fall stone, but for convenience thought he would use some of the blocks of Calverley grit scattered about so plenteously. But when these stones arrived at York they were found to be of no use, for none of the tools would touch them. From the top of this remarkable rock Mr. Cheetham had been asked to favour the company with an address on "The Geological Anatomy of Airedale," but one of the sharp April-like showers, which have been so common this summer, coming on quite suddenly, the party were only too glad to find the hanging-stone an overhanging stone, and sheltered by this great natural umbrella we listened with deep interest and attention to our leader's lucid and racy remarks. The valley of the Aire, Mr. Cheetham said, had been his first geological lesson-book, and the scene spread before us reminded him of many pleasant excursions under the leadership of Professors Green, Miall, and Tate. From the coloured map in "West Yorkshire" (Davis and Lees) it will be seen that the watersheds of the Wharfe and the Aire are about equal in area. The Aire, however, winds considerably more than does its sister river, the Wharfe being 52 miles as the crow flies, but 80 following the banks; whereas the course of the Aire is 57 miles direct, and 92 miles following its windings. An ungeological way of accounting for this excessive curvature is preserved in the myth that the goddess who traced the course of the Aire bargained for a kiss for every bend. If so, we will hope she was not surfeited!

The Aire is formed by the union of several streams which take their rise near the base of Fountains Fell. The two principal feeders flow eastward from Capon Hall, the northerly stream falling into Malham Tarn, whilst its southern companion passes for a mile or so over flats of Carboniferous Limestone, locally called "streets," and sinks into a fissure near an old mill. The stream emerges from the southern end of Malham Tarn, 1,250ft. above sea-level, and after flowing due south for half a mile over Silurian beds, plunges into a large swallow hole filled with blocks of stone. Before this fissure was enlarged sufficiently to swallow up the whole stream, it, no doubt, travelled the rest of the distance on the top of the limestone to Malham Cove, forming the grand cascade, from the sheer height of 285ft., by which the Cove has been cut back. These becks after flowing underground in cavernous recesses reappear united as a good stream of beautifully clear water at the base of this precipice, another branch of the stream issuing at Airehead.

Flowing southwards, the river immediately crosses the Great Craven Fault and passes on to Yoredale beds, some thousands of feet higher up in the geological series than the Silurians of Malham Tarn. This section admirably exhibits the tremendous character of the earth movements which accompanied the formation of the Pennine Chain

After passing through Malham, the Aire is joined by Gordale Beck, which, until 1730, fell over the edge of Gordale Scar; but during a heavy thunderstorm in that year it burst a new way through the opposing wall of rock, forming a large natural arch. The river then flows in a south-easterly direction over Yoredale grits and shales, until near Skipton, at a height of 350ft. above sea-level, it crosses the well-known anticlinal of Carboniferous Limestone, after which it immediately pursues its way through the beds of the Millstone Grit series, having elevated moorlands on either bank, to Newlay where it enters the Lower Coal Measures. Thence by Kirkstall Abbey it flows to Leeds, the pure crystal of Malham having now given place to the malodorous inkiness by which the Aire is best known to our townsmen. Passing Leeds Bridge at a height of 90ft. above sea-level, the Aire runs eastward across the Upper Coal Measures to Castleford, where it is joined by the Calder. The combined stream then cuts through the Magnesian Limestone escarpment, and flows thence over the level Triassic beds to join the Ouse near Goole.

There is ample evidence that this deep, winding valley is the result of the carving power of the river, for on either side we find the same succession of beds. Though in some parts the original flow of the river may have been determined by a fault, the present contour is due entirely to the action of the sub-aërial denuding agencies, except where modified by man. For instance, the Calverley stone is the Rough Rock, the uppermost bed of the Millstone Grit series, and on the other side of the valley we find the same beds at Rawden. Again, capping Baildon Hill, is an outlier of the Lower Coal Measures, containing two seams of coal, called respectively the Hard and Soft Bed coals. These were worked in olden times by means of bell-pits, the remains of these workings being still visible. On the southern side of the river at Idle the same beds of coal are found at a rather lower level, owing to a fault which runs parallel to the bend of the valley, these coal seams having been, previous to faulting and denudation, continuous across the site of the valley.

Having made America the starting point of his description of Wharfedale, our lecturer alluded to the proximity of the hanging-stone to Canada and New York, Canada being 1¾ miles N.N.E., and New York 1¾ miles N.E. He traced the origin of these names to the great American boom of 1825-6, followed by a sad depression until 1829, during which so many people were forced to work on the roads for a mere pittance. Prior to this there were no roads along the bottom of these valleys, which were occupied in olden times by bogs and swamps. The present main roads were constructed about 1857. Mr. Cheetham then referred to the interesting beach and glacial deposits in the neighbourhood of Newlay, and showed a piece of delicate branched coral which had been dug out of a boulder deposit during the excavation for the new gasholder. The reason why this fragile coral had been preserved was as follows:—It had originally been embedded in a solid block of Mountain Limestone, but the percolating water had carried away the limestone which filled the interstices, leaving behind the harder and less soluble material of which the coral skeleton was

formed. A specimen of the same kind of coral was shown forming part of such a block of marble. Mr. Cheetham then referred to railways, and what they had done for the popularising of geology. The cuttings, he said, frequently expose far better sections than would otherwise be seen; as, for instance, the splendid sections of faults near Guiseley. They also enable geologists to see far more real geology than previously was the case, for our science can only be studied in the field, Nature's great workshop, and so railways have helped to raise geology to its true level, and to dissipate the idea that it has only to do with antiquated fossils in a museum.

At the close of Mr. Cheetham's remarks the party adjourned to one of the quarries, where a picnic tea was provided. After tea, a hearty vote of thanks was proposed by the President (Mr.C.Brownridge, F.G.S.), seconded by Mr. C. D. Hardcastle, to Mr. Cheetham for his admirable address, to the Vicar and Mr. Margerison for their courtesy at the church, and to Messrs. Gray and Thornton for their kind hospitality. After tea a visit was paid to the quarries, in which splendid sections of the false-bedded Rough Rock were viewed by the light of a glorious sunset. The party then, well satisfied, strolled back to Calverley in good time for the 8.8 train to Leeds.

SEPTEMBER 11th, 1890.

EXCURSION TO MALHAM AND GORDALE SCAR.

BRITISH ASSOCIATION, AND YORKSHIRE NATURALISTS' UNION.

Leaders, MR. R. H. TIDDEMAN, M.A., F.G.S.,

and MR. J. W. DAVIS, F.S.A., F.G.S., F.L.S.

The morning opened dull and grey and the goodly display of waterproofs betokened the distrust of the members in the intention of the weather, which did not promise well for a six miles' walk over Yorkshire moors. Fortunately, however, the low and threatening clouds slowly broke before a strong breeze, and when Bell Busk was reached the sun had asserted its supremacy, and gradually cleared away the clouds and mists that were hanging ominously around Fountains Fell and other of the Craven Hills.

After a short delay at the station, caused by the late arrival of the conveyances, the journey was resumed, and passing Calton on the right (the birthplace of Major-General Lambert, one of Cromwell's Parliamentarian Generals) Kirkby Malham was reached. A visit was then made to the interesting old church, which is a good specimen of north country Perpendicular. The Vicar pointed out its interesting features—the old font, pillars with saint niches cut in the western face, and the old register, containing an entry of marriage signed by the Protector, which occasioned great interest.

Most of the party continued the journey on foot along the western side of the Aire, so as to see Airehead, where a portion of the water from Malham Tarn, after travelling underground for over two miles,

makes its appearance from a fissure in the surface covered with stones.

After lunch, at Malham, the Geological Section, which was a very numerous party, at once set out, under the able guidance of Mr. R. H. Tiddeman, M.A., F.G.S., and Mr. J. W. Davis, F.G.S., F.S.A., to visit Gordale Scar. At a suitable point, commanding a good view of the neigbourhood, Mr. Tiddeman (who geologically surveyed this district) gave a brief outline of the geology, and pointed out the physical features of the country.

The Mid-Craven Fault, south of the Cove and Scar, runs in an almost east to west line, bringing the Pendleside limestone of the southern area against the Mountain Limestone of the northern area. The limestone on the south side of the fault is of two kinds, dark and light coloured; the former regularly bedded and well stratified, while the latter is irregularly bedded and of massive character, rising in big conical-shaped mounds, resting usually on the black limestone. These masses Mr. Tiddeman terms knoll-reefs, and described them as having been formed in a similar way to coral reefs—by upward growth and piling up of *débris* by wind and waves. This action has evidently gone on in shallow water on a slowly sinking area, and seems to indicate the islands and shallows of a deeper area in which the dark beds were being deposited. As these rocks are not found north of the fault, but are as it were walled in by it, this would seem to indicate the existence of two areas of deposition, and that these rocks were being deposited during the movements forming the Craven Faults, and thus accounts for the dissimilarity between the two series.

In passing along the road a good exposure of a moraine was noted, and after a passing visit had been paid to Janet's Cave and Fall, the party crossed the line of fault, clearly marked by the different coloured vegetation, proceeded up Gordale Beck, where several typical springs issue from the hill-sides to swell the volume of the stream, and entered the grand gorge of Gordale Scar. Here the limestone cliffs rise up 300 ft. high, and overhang on each side, having been worn away by the action of the rapid mountain stream which runs at the base. At the head of the gorge, evidence can be clearly seen of this action going on at the present time. The stream, leaving its old course, has burst a new channel through rocks to the east, and above hangs a mass of rock seemingly ready to aid in the extension of Gordale Scar; while the line of a small fault near, which runs across the valley, has opened a large fissure to further augment this work.

After an arduous climb, in which the ladies showed great courage and endurance, the moorland plateau was reached. A part of the party, guided by Mr. Tiddeman, made a detour to Malham Tarn to see an exposure of the conglomerate bed at the base of the Mountain Limestone, while the remainder, under the care of Mr. Davis, proceeded to the "Watersinks."

The North Craven Fault, which runs across Malham Moor, though its line is much obscured by drift, having a throw of several hundred feet, brings up the base of the limestone. The limestone being worn away has left a watertight surface, upon which the shallow tarn has been formed by the drainage of the south-eastern spurs of

Fountains Fell. The overflow from the tarn, after passing over-ground for half a mile, encounters one of the numerous fissures with which the limestone is intersected, and disappears through two holes at "Watersinks," to ultimately reappear at Airehead and Malham Cove. These watersinks are forming what will ultimately become pot-holes, similar to Gaping Ghyll, on Ingleborough, and Hunt Pot, on Penyghent. The question of the true source of the Aire has always been an interesting one, and experiments made by members of the Yorkshire Geological Society in 1879 proved that the waters of the tarn, when suddenly discharged, affected the outlets at Aire Head and Malham Cove at different intervals. It arrives at the former 38 minutes before it affects the water at the Cove, although the Cove is $1\frac{1}{4}$ miles nearer. Professor Dawkins suggests that there exists under the Cove a large water cave with a wide, uneven floor, over which the water will pass slowly, while the passage to Aire Head may be by a narrow, straight fissure, down which the water would pass more quickly. The British Association, by its recent grant of money to investigate the sources of the Aire, will no doubt cause further light to be thrown upon the subject.

Passing along what is said to be the old bed of the stream, fine examples of denudation were seen on the faces and tops of the scars on each side of the valley, and, after numerous walls had been surmounted, Malham Cove was reached; here again the limestone towers above in a fine circular-shaped cliff, 285 ft. high, from the foot of which the water issues. The cliffs stood out in remarkable whiteness, and seemed, as the leader facetiously remarked, "to have been especially whitewashed for the occasion." Opinion differs as to the agency by which this fine cliff has been formed, but it is most probable that the rock, shaken by the Great Craven Fault, which runs several hundred yards to the south, has been worn back by sub-aërial agency, the stream helping the process by clearing away the *débris* at the base.

After leaving the Cove, Malham village was at once made for, and the sign of the Buck, betokening a well-earned tea, was welcome to all.

The clear, fine day and interesting district tended to make the excursion one of the most enjoyable of the Yorkshire Naturalists' Union session, and gave the British Association visitors the best opportunity for studying the geology of a district so rich in interesting physical features; and the whole of the members gladly acquiesced in a cordial vote of thanks to the leaders, passed at the meeting held after tea on the steps of the hotel. C. B.

SEPTEMBER 11TH, 1890.

EXCURSION TO INGLEBOROUGH.

BRITISH ASSOCIATION.

Leaders, Mr. J. E. BEDFORD, F.G.S., and

Rev. E. MAULE COLE, M.A., F.G.S.

Of the fifteen excursions arranged by the Committee of the British Association the Ingleborough trip was moderately popular, and resulted in eighteen or nineteen applications for tickets. Possibly the notification that the distance to be walked by the party was from 7 to 10 miles, according to the route taken, prevented those attempting it who did not feel equal to such a distance in a hilly country. Another explanation of the small attendance might be found in the fact, that, in this case there was no Lord or Earl providing hospitality for the party. This latter addition to the scientific fare provided proved an immense attraction to those excursionists who visited some other districts, as evidenced by the application for tickets far exceeding the estimated limit. However, nothing daunted, the brave little party set out from Clapham station at a good swinging pace, and each one who looked around at the beautiful prospect of hill and dale, wooded ravine and rocky crag, spread out before him, must have felt delighted and fortunate in his happy choice of Ingleboro' for his day's hunting ground. The weather was perfection, bright and clear, and the air had the sharp taste and exhilarating effect of ozone. The village of Clapham about a mile from the station was soon reached and its beauties called forth many expressions of admiration from the visitors. The trees were at their best, the cottages were ablaze with flowering creepers, and the little gardens a mass of colour. Permission had been granted to the party to pass through the picturesque grounds of Ingleborough House, the residence of J. A. Farrer, Esq., and this enabled the party to view Clapham tarn and waterfall. The owner now utilises the water power for producing the electric light for use in his mansion. The north Craven Fault crosses to the S.E. near the head of the tarn and the Silurian rocks are exposed. The Ingleborough Cave was the next point of interest, or, possibly, the excellent luncheon there provided. The whole party with one solitary exception passed into and along the whole length of the cave, and all appeared to be greatly interested in it. The usual guide's description of the wonderful "bee hives," "organ pipes," "elephants' feet," etc., which are pointed out to visitors, may safely be omitted, and reference only made to a few points of interest which strike any observer who takes the trouble to study the conditions under which the channel has existed. There is evidence to show that the cave has been the bed of an underground stream which has gradually enlarged its channel by dissolving the limestone. It must also be connected by some pot-hole, possibly Gaping Gill, from the fact that the boulders and pebbles found in the cave are generally grits from above the limestone. There is evidence to show that at intervals a fierce torrent has rushed along the bed of the long winding

passage, as the sides are much waterworn, or ground by the attrition of pebbles carried by the stream. Patches of gravel cemented by calcareous percolations are still attached to the sides, in some cases close to the roof, or lying on ledges of rock and in out of the way corners. These point to a time when the cavity was nearly filled with deposits of this nature. Much of this *débris* was removed by the late Mr. Farrer to improve the passage through the cave, and to determine its limits. Some portions of the cave contain stalactites and stalagmitic bosses which must have taken centuries of undisturbed conditions to form, and at one point a dam has formed of travertine, similar in chemical composition to stalactite, and must at some time have contained a pool of water, bright and clear, composed entirely of droppings from the roof, water saturated with carbonate of lime. This is inferred from the peculiar formation of the rim or lip of the dam, which is carbonate of lime, and is exactly similar in form to the incrustations around the natural basins of many hot springs in various parts of the world, such as those of the Yellowstone district of America or the basins of the recently destroyed Pink Terraces of New Zealand. The formation of stalactites was noticed, also the different forms of stalagmites immediately below them. Some of the latter were short, broad, and dome-shaped. Others were slender pillars varying from half an inch to one and a half inches in diameter, and from a few inches to a foot or more in height. The formation of these tall and slender shafts required elucidation and the process was observed later on. In all cases where a tall and slender stalagmite had formed there was originally a delicate tube of carbonate of lime depending from the roof, but now many are without any sign of a stalactite ever having been there. The tube is no thicker than a straw, and the water charged with carbonate of lime occupies the interior. The diameter of this tube is so narrow that the water is retained by capillary attraction in its interior and only drops slowly from the open end. It thus grows in length until it approaches the ground, say two feet away, where it builds up a slender column to meet it, by always dropping on the same spot, and so slowly as not to cause much splashing, and to give time for the escape of the carbonic acid in the water and the deposition of the lime on the point of the stalagmite before the arrival of the next drop. Very few of these slender tubes have escaped the fingers and walking sticks of mischievous people. Before leaving the subject of the cave it may be stated that the stream which originally ran through the cave now issues at a lower level at the bridge, a few yards from the cave.

The party proceeded up the valley or ravine to see Trow Gill, noticing on the way several similar openings in the limestone face, evidently old water courses. On arrival at Trow Gill a few remarks were made by the leaders on the geology of the district, and on the formation of this curious "canon." There seems to be sufficient evidence to lead one to believe that the stream which drains the southern flank of Ingleborough, once descended this way by means of an underground channel from a pot-hole at the head of the glen, and that Trow Gill was then a cave like Ingleboro' cave, the roof

having since fallen in, leaving it in its present curious condition. The stream above mentioned is now repeating the same thing higher up the hill. There it flows a short distance along the surface, over shales above the limestone, and over patches of glacial drift overlying the limestone. Soon after reaching the bare limestone it plunges down the abyss of Gaping Gill Hole and flows away underground, coming out, it is thought, along with other underground waters, at the stream which emerges near the cave. It is quite easy to understand how the stream could flow over the intervening limestone and descend by Trow Gill, if we remember that these rocks were at one time covered with shales and by glacial drift which would make them moderately water tight. The old bed of the stream running in the direction of Trow Gill was easily followed, passing along the brink of a large opening in the limestone plateau caused by the rock falling into some cavity existing there, and illustrating in a splendid manner the theory of the formation of Trow Gill. The leaders then gave a geological description of the district as viewed from the limestone plateau, the correspondence between the hills Ingleborough and Penyghent was pointed out, and the position of the Millstone Grit and Yoredale rocks was referred to. A section illustrating this was presented to the visitors. A bed of coal exists in the Millstone Grit series on Penyghent, and on Fountains Fell no less than seven seams have been proved by boring, according to the Geological Survey. These coals have been extensively worked, the main seams are 2ft. 4½in. and 2ft. 6in. thick. The drift on Ingleborough "rises to 1,600ft. on the northern abutment, and nearly to the same height on the west, and to 2,000ft. on the S.E. side." It occurs also in "patches on the main limestone of Simon's Fell, and on the south side of Ingleboro'." The "drift is local, consisting of ground up carboniferous shale and sandstone." (*Geological Survey*). Beds of peat occur on the bare limestone plateau, only where thin beds of drift overlie the limestone and make it water tight. The bedding of the rocks is nearly horizontal in this district but with a slight dip to the east. All the hills and valleys are the results of denudation from a plateau of the above-mentioned rocks. Hundreds, or in fact thousands of feet of sandstones and shales have been removed in this way, and the little coal-field of Ingleton bears testimony to the amount of material thus removed. It contains a patch of a long lost coal-field faulted down some thousands of feet into the earth, a coal-field whose position was high above the grits on the top of Ingleborough, and which doubtless extended across the Pennine anticlinal, joining together the Yorkshire and Lancashire seams. After inspecting Gaping Gill Hole (360ft. deep) some members of the party ascended Ingleborough and were well repaid by the splendid view they obtained from the summit. Another portion returned to Clapham *via* Crummack Dale and the Norber erratics. This party struck across the moor for the head of Crummack Dale, and were rewarded by a magnificent panorama of the limestone plateau and scar as seen from this point. Moughton Fell formed the opposite side of the valley, Penyghent stood out in bold outline beyond, and to the N.E. was a stretch of moorlands including Cam Fell in the distance. The position of the Lower

Silurian beds (the Coniston Limestone) in the valley bottom was pointed out, also the limestone screes or talus sloping from Moughton Fell by the weathering of the limestone. Passing down the valley, various exposures of Silurian rock were noticed, and some fine examples of glaciated surfaces with striæ or grooves running parallel to each other, caused by the moving ice. The Silurian at this point rises into a bold ridge running diagonally across the valley. It has been broken up by the glacier passing over it and an enormous number of massive blocks lie in confusion in front of this ridge. Beyond, the blocks have been forced along the limestone plateau, and form fine examples of perched blocks resting on pedestals of limestone. The party then returned to Clapham for dinner at the New Inn. J.E.B.

SEPTEMBER 27th, 1890.

EXCURSION TO SCARBOROUGH.

Leader, Mr. J. W. PHILLIPS.

Five hours at Scarborough for two shillings enabled some members of the Leeds Geological Association to explore the recent changes in Castle Hill, under the able leadership of Mr. J. W. Phillips, the curator of the Philosophical and Archæological Society's Museum. Starting punctually from the New Station, Leeds, we were soon rushing eastward at a fair speed, with hardly time to notice some good sections of Coal Measure sandstone in the cuttings, and a clean cut through a coal seam. Near Garforth we entered the overlying Magnesian Limestone, thin-bedded in its lower parts but more massive higher up, and dipping gently to the east. Catching a glimpse of Sherburn Church, crowning a slight eminence to the right, we entered the wide Vale of York, leaving the Magnesian Limestone ridge for a level stretch of overlying Triassic strata, mostly covered by glacial deposits. Soon "all tickets ready" reminded us we were at York, and passing through the handsome Railway Station, our eyes were delighted with a sunny peep at the old city and its grand old Minster. Then on again over rich pastoral country to Malton, any monotony in scenery being amply relieved by an animated discussion on the comparative merits of the dialects of York and Aberdeen. Soon the wide moorland flats of Strensall Common were reached, and the monument at Castle Howard looked down on us from the rising ground on the left. After a passing glimpse of ruined Kirkham Abbey by the side of the Derwent, pleasant Malton appeared to view, the sun shining gaily on its red-tiled roofs, and promising a glorious afternoon. At Rillington there was an interval of shunted meditation, until the express dashed past and left the way open for us to follow on. Thence our way lay along the Vale of the Derwent, separating the northern Oolitic hills from the southern chalk uplands, which ran on either hand in parallel low ridges, cultivated or wooded to the top. The hedges, red with hawthorn berries, reminded one member, but lately returned from the Isle of Man, of the large fuchsia hedges which adorn

that gem of the sea, and the patriotic soul within him found relief in the inspired burst—

For all the ills that flesh is heir to
Give me the Ilkley hills, and Aire too.

Probably he was thinking of Malham and its limpid waters.

Scarborough was soon reached, and our guide quickly piloted us by the nearest route to the object of our excursion—Castle Hill. The view from the top, 286ft. above sea level, was very fine. Out eastward lay the deep blue of the North Sea, only disturbed by the slow ripple of lazy wavelets, while north and south cliff after cliff jutted out with a fringe of white foam at its base, and far southward the white cliffs of Flamborough shone clear in the bright sunlight. The position of the faults which make the geology of Castle Hill so complicated and interesting was indicated, the actual junctions being now mostly covered up. Owing to this faulting the hard Kellaways Rock, which forms a ledge at the north base of the Castle Hill, underneath the Oxford Clay, is found underneath the gateway 150ft. higher up faulted against this clay bed. Crossing the line of fault a good section of the Middle Oolitic beds was seen. On the top of all, forming a precipitous scar, are the lowest beds of the Coralline Oolite, underneath which come the Passage Beds and then the Lower Calcareous Grit, which is ironstained and contains bands of "ball stones"—boulder-like concretions. In the middle of the Lower Calcareous Grit beds there is a cherty bed which weathers out prominently. Underneath these comes a thick mass of Oxford Clay. The party then proceeded to investigate the effect produced by the recent landslip. This has considerably altered the north-eastern point of the Castle Hill, a huge bank of stony blocks covering the lower half of the cliff. The way in which some of these blocks have been left standing is very remarkable; one in particular, estimated to weigh 20 tons, stands on another, both of which appear to have fallen during this landslip, poised on a fairly flat surface at an angle of 40 degrees, apparently wanting but a push to heel over. After searching the Oxford Clay and Coralline blocks for fossils, the party re-ascended the hill to examine the great fissures which have opened parallel to the landslip, and which promise further dislocations during the winter. Photographs of these were taken by Mr. A. E. Nichols, which will, no doubt, be of considerable interest to the committee which is investigating the coast erosion of Yorkshire. After tea there was time for a pleasant ramble along the Promenade, the sea shining under the full moon like molten silver, and through the palatial Spa, with its beautiful walks and terraces, to the enlivening strains of an excellent band. Then tearing ourselves reluctantly away from the illuminated bay of the "Queen of Watering Places," we sought the station, and reached Leeds in good time, pleased and benefited by our trip—especially any, perhaps, who had been wise enough to take a draught of something cold, so convincingly recommended as especially "good for your livers and your nerves." A hearty vote of thanks was accorded to Mr. Phillips for his pleasant and instructive guidance.

MARCH 7TH, 1891.

VISIT TO THE LEEDS MUSEUM.

Leader, PROFESSOR L. C. MIALL, F.G.S., F.L.S.

The members of the Leeds Geological Association commenced their practical excursions for the season by paying a visit to the Leeds Museum, where they were met by Professor Miall, F.G.S., F.L.S., who had kindly consented to conduct the party. Instead of attempting too much, the attention of the members was concentrated on a few typical and specially interesting fossil remains, and in this way the educational value of the visit was considerably enhanced. The first fossil inspected was Eozoön, of which there are several fine specimens in the Museum. This fossil is supposed by many to be the oldest evidence of life on this globe; but other authorities boldly combat this view, and maintain that the structure is wholly inorganic, and that the appearance of animal growth is really deceptive. At present this question is *sub judice* and we must await the result of further investigations before the exact affinities of this ancient Canadian fossil can be decided. Some of the interesting Cambrian and Silurian crustaceans, called Trilobites, from their tri-lobed structure, were next examined. The division of the test into head, body, and tail was pointed out, and several coiled specimens were exhibited, showing that trilobites had the power of rolling themselves up when threatened by enemies, to preserve the soft under-parts of the body from attack. Some evidently had been buried whilst thus on the defence. The influence of pressure in producing slaty cleavage on the particles of a rock-mass was well shown by a distorted trilobite from the Tremadoc Beds. This specimen showed that there had been a regular movement of all the particles of the rock in a definite direction, producing a peculiar distortion of the fossil. A good series of fossils from the Mountain Limestone of Settle was next exhibited. A very interesting slab in the same case, from Eskdale, Dumfries, showed a number of shrimp-like crustaceans. The splendid fossil-fish, Megalichthys, found in the Coal Measures at Idle in 1883, then attracted the attention of the party. This specimen, the Professor said, was one of the finest fossil fish ever obtained from the Primary formations, and shows the whole ventral surface. Another fossil, a small, deeply grooved plate, from the Coal Measures at Tong, was shown as having a specially interesting history. It was examined by Agassiz, the celebrated writer on fossil fish, when he visited Leeds fifty years ago. He concluded that it was the palatal tooth of a fish, and that another one had existed, forming a pair on the roof of the fish's mouth. Many years afterwards his sagacity was strikingly shown by the discovery of another specimen, which exhibited the two palatal teeth and the bones of the palate complete. The discovery of an allied form in the living Ceratodus of Australia has enabled this structure now to be fully studied. Some interesting reptilian remains from the Secondary rocks were then examined, the beautiful electrotype casts of Labyrinthodon remains from Bohemia arousing considerable interest. In another room some

hand-like tracks were shown from the New Red Sandstone, which formerly were attributed to the Labyrinthodon (so called from the curiously complicated plications of its teeth), as it was the only large animal whose remains had been found in that formation. The resemblance of the track to that of a frog was very striking, and so it was concluded that the Labyrinthodon was a frog-like animal, and had produced these tracks. But subsequently it was pointed out that the frog was essentially suited for leaping, and that an animal with a heavy bony skull, 2ft. 6in. long, could not have been fitted for such a method of progression. The Labyrinthodon is now considered to have been a creature more like a crocodile, with a long tail, and suited for an aquatic life. In another part of the room attention was directed to the footprints of the Iguanodon, a gigantic reptile from the Wealden Beds of Sussex. Tracks have been found in these beds 2ft. 6in. in length. Professor Miall put together the bones of one toe in the Museum, which proved to be 1ft. in length, and had evidently ended in a claw. These toes were shown to closely resemble those of a bird, thus evidencing that these extinct animals were to some extent intermediate between reptiles and birds, partaking of the characteristics of both, and thus giving evidence that though these two vertebrate classes are now so clearly separated, they have had a common ancestry. A number of typical Chalk fossils were also shown, the contrast between the forms which the Chalk beds contain in different areas being especially dwelt upon. A certain assemblage of fossils is found in the Chalk of South Britain, Northern France, and Saxony; whilst in Southern France, Italy, Greece, Egypt, and Syria, beds of the same age contain widely different forms. This points to the existence of a ridge across mid-Europe dividing the Cretaceous Ocean into two Mediterranean-like seas, in each of which a certain assemblage of animals found a home, but between which there was no direct communication.

At the close a hearty vote of thanks was given to Professor Miall for his interesting and lucid description of these ancient relics.

MAY 18TH, 1891.

EXCURSION TO LECKBY CARR.

YORKSHIRE NATURALISTS' UNION.

Leader, Mr. T. C. MITCHELL, F.S.A.

Probably owing to the Christmas-like weather this Whitsuntide there was not so large an attendance as usual at the opening excursion of the Yorkshire Naturalists' Union. However, a goodly company assembled about half-past ten o'clock at Brafferton Station, from which a start was made for Leckby Carr, where the work began.

Leckby Carr is a wood situated in a swampy hollow within a few hundred yards of the right bank of the river Swale, but separated from that river by a gravel ridge. Originally, in all probability, this hollow had a natural drainage into the Swale. During the Ice period,

a glacier, having its origin in the hills far away to the north-west, and more or less following the course of the river, brought with it vast quantities of shingle, gravel and sand, forming a moraine, which, when the ice disappeared on the climate becoming milder, was left as a range of large mounds of gravel along the valley. The hollow, thus converted into a shallow lake basin, in time became to a great extent filled up by the growth of aquatic plants. Around the outside of the Carr the ground is firm, and some good timber trees grow on it, but further in it has never been thoroughly drained, and is neither water nor "good dry land." It has been long looked upon as a "happy hunting-ground" for the naturalist.

The biological sections worked chiefly in the Carr itself, under the leadership of Mr. W. D. Roebuck, whilst the geologists went on farther, under the guidance of Mr. T. C. Mitchell, F.S.A. Their first visit was paid to the gravel pits, which were found to be full of rounded pebbles of grit and limestone from the Carboniferous rocks, as well as others from beds ranging from the Silurians to the Lias.

A large boulder of shap granite was seen in the river bed not far from Leckby Carr, which indicates with great accuracy the direction in which the flow of ice must have taken place.

In consequence of an extensive double fault which occurred after the deposit of the Chalk, and which reaches from the East Coast to the Magnesian Limestone a few miles north of Ripon, the Lias formation still remains unremoved by denudation so far westward as this district, whereas on both sides of the fault the Trias extends some miles further to the east before it underlies the Lias.

The leader then conducted the party to see two sections of the Lower Lias beds exposed in the river bank. The first section visited was near the gravel pits, and consisted of a mass of Lias clay with fossils, much crushed by glacial action. The under surface which was uneven, rested on a deep red sandy clay, and was overlaid by two feet of river sand. The question as to whether this bed was *in situ* was earnestly discussed, but there did not seem sufficient evidence in this section to warrant an alteration of the line of fault marked on the ordnance map. Mr. Mitchell, however, stated that he had found Lias fossils considerably south of this line, and had been informed that in boring for water on the hill near Cundall Vicarage, Lias beds were found at a considerable depth.

Near Asenby the Swale makes a sharp bend, and has eaten into the cliff, exposing a good section of the Lower Lias beds. They consist of tenacious, blackish clay, with bands of concretionary limestone at intervals. After photographing this section, a start was made for Baldersby Park, where a fine erratic of Millstone Grit, weighing, probably, three tons, was examined, measured, and photographed.

The ravages produced by the recent storm and severe frost were very evident, the beeches and elms especially being changed from a vivid green to a blighted brown. The fruit trees also had suffered severely. At many points between Leeds and Brafferton the hills were white with snow, which also lay in the fields over considerable areas. On the return to Helperby there was opportunity to admire the

beautiful undulating country backed by the ridge of the Hambledon Hills, which stood out with unusual clearness in the bright evening sunlight. The little village of Topcliffe surrounding the fine old church looked especially pretty.

After tea at the Golden Lion Inn, Helperby, the Sectional and General Meetings were held in the Helperby Mechanics' Institution, Mr. Chas. Brownridge, F.G.S. presiding. After the preliminary business had been concluded, a vote of thanks to the Dowager Lady Downe and Mr. Basil T. Woodd, J.P., D.L., for their kind permission to explore Leckby Carr and to visit Baldersby Park and Woods, was proposed by the Rev. A. Gill and seconded br Mr. W. H. Pawson. The sectional reports were then presented, and the proceedings terminated with a vote of thanks to the chairman.

JUNE 6TH, 1891.

EXCURSION TO THE WINTERBURN VALLEY.

Leaders, Mr. W. CHEETHAM, and

Mr. R. H. TIDDEMAN, M.A., F.G.S.

A dull, leaden sky and an ominous weather forecast was not very assuring to the members of the Leeds Geological Association for their visit to the Winterburn Valley, but notwithstanding the dark outlook a party of twenty-four assembled at the Midland Railway Station "prepared for contingencies," and travelled by the Ingleton trip train, which by the courtesy of Messrs. Cook and Sons and the Midland Railway Company was specially stopped for their convenience at Gargrave. Here King Sol had fortunately asserted his supremacy, and now shone forth with all his power, making the quaint and pretty village look even cleaner than is its wont, and inspiring the party by his brightness and power to step out with lighter hearts to the scene of the day's proceedings, which, according to the notice, contained "no hotels," or, as might be interpreted, "no shelters."

Passing through the picturesque village, through which the Aire runs in its earlier purity, the river shone out, a streak of dazzling light, and seemed to be merrily reminding the party that it was not always the dirty and neglected stream they were in the habit of associating with its name. Wraps and mackintoshes having been left in charge of mine host of the White Swan, one portion of the party under the charge of Mr. Cheetham proceeded by conveyance, while the other and larger party set out by way of the fields and woods of Eshton under the care of Mr. E. G. Bateman, of the Leeds and Liverpool Canal Company. Getting clear of the village and roads the party were soon in the midst of a scene of rustic grandeur, the fields rich in their cloak of wild flowers, whilst the woods stood out a vivid mass of bright spring colour. The ash, sycamore, larch, and thorn towered up to a gigantic size, and the copper beech stood out more red by contrast with the spring greens, seeming a mass of bright fire in the landscape, whilst the heron starting up from its retreat reminded the party they

were intruding into parts little troubled by the foot of man. Towering up on the right the jagged top of Flasby Fell seemed to keep watch on the scene of quietness below, and beyond Scarnber, Eshton Moor, and Malham Moor shut in the scene from the outer world. Passing by Brocka Bank a short stop was made to admire this picturesque farm-house with its pump standing as a picturesque object of utility in the front garden. The party then descended the hill to Friars Head, a fine picturesque mansion of the 16th century, with its four quaint three-storeyed gables flanked by large trees, seeming only to want the figure of an old Parliamentarian to carry one back to the days when Major-General Lambert, one of Cromwell's generals, was a near neighbour at Calton, just over the hill. Several fine exposures of limestone were noted resting at high angles, showing the great amount of force these beds must have been subjected to since their deposition, while here and there the serrated edges of the rock asserted themselves in the bed of the stream, and opposing its even flow, gave protection against the rapid wearing away of the shales adjoining. On arriving at the reservoir, it was ascertained with pleasure that Mr. R. H. Tiddeman, M.A., F.G.S., of the Geological Survey, had come to join the party, with Mr. Wilkinson, a Skipton member of the Association. As Mr. Tiddeman's name is directly connected with all the work of unravelling the geological problems of this and the adjoining districts, his presence was properly looked upon as a great feature in the day's proceedings. An examination of the exposure of the Pendleside Limestone on the east bank of the reservoir was made. The lower beds are here of the black limestone, well bedded with shaly partings. The upper is of white reef limestone, with little bedding. The rock in places was seen to consist of a close breccia, containing angular fragments of limestone, the beds being almost vertical, and making a quick turn they run across and form the base of a portion of the puddle trench.

After a pleasant rest, and tea, partaken of in the reservoir keeper's house, the party, now numbering over 30, under the guidance of Mr. Tiddeman, proceeded up the bed of the reservoir to examine the glacial deposits which here contained many fine examples of ice scratched boulders, photographs having been obtained of a monster one weighing several tons, and having fine groovings or striæ. A visit was made to Calf or Way Gill to examine the Bowland Shales. These were seen finely exposed resting on thin bedded hard limestone, and contained fragments and large detached boulders of limestone. Mr. Tiddeman is of opinion that the source from which these boulders and fragments have been derived is some reef or knoll, which may possibly be hidden under the drifts and shale. The boulders, after being rolled about on the floor or ledge of the reef, have been washed down and deposited among the softer shale deposits of the deeper waters. The shales were seen curving round to the shape of the boulders, showing their deposition while the shales were still in a soft plastic form. Mr. Tiddeman gave the members a brief outline of the geology of the district, pointing out in illustration the various features in view to illustrate his remarks. This district until recent years has been a

puzzle to geologists to know how it came about that these well-known series of limestones forming the Yoredale beds ran with such regularity over the great area of the Yorkshire dales, and yet were not recognisable over the southern part of Craven. It was assumed that there was a rapid transition of type in the Carboniferous rocks between Clitheroe and the big fells north of Malham, but no explanation of this could be given. By Mr. Tiddeman's efforts it is now known that there is no transition, the two types run unchanged in their respective areas up to a common boundary formed by the Great Craven fault, which passes between Malham Cove and Malham, and runs on the north of the Winterburn valley. The rocks in the southern area in descending order are found to be Coal Measures (Ingleton) 1,500ft., Millstone Grit 3,900ft., Bowland Shales 300-1,000ft., Pendleside Grits (inconstant) 0-250ft., Pendleside Limestone (with knoll reefs) 0-400ft., Shales with Limestone 2,500ft., Clitheroe Limestone (with knoll reefs) over 3,250ft. The rocks in these northern and southern districts seem to have been formed on slowly subsiding areas, the southern area subsiding more quickly and to a greater extent than that occupied by the Yoredale type. The Craven faults going on during the deposition of these beds caused the dissimilarity between the two series. The limestone of the southern area is of two colours, dark and light-coloured, distinct in bedding and lithological character. The dark variety is found evenly bedded, with shaly partings, well stratified, and extending over considerable areas; the white limestones south of the fault occur in large bosses with irregular bedding. These conical mounds, usually rest on black limestone; they are rich in fossils which from their perfect form appear to have lived and died there. From the form and shape of these mounds and their structure it seems that the reefs have been formed by upward growth of coral, and piling up of *débris* by the wind and waves. That these reefs have been exposed to the work of the waves is evident by breccias composed of fragments of limestone being abundantly found.

All the points of interest, many of which will shortly be lost beneath the waters of the reservoir, having been examined, the members retraced their steps to the lodge, and assembling together a cordial vote of thanks, proposed by the President and seconded by Mr. Cheetham, was accorded to Mr. Tiddeman for his assistance in personally explaining the many geological features of the valley, with the "original" diagrams to illustrate the many difficult problems presented in its geological history. A hearty vote of thanks to Mr. E. G. Bateman for his assistance and guidance, and who along with Mr. Cheetham instigated the excursion, was accorded on the motion of Mr. W. L. Carter, M.A., seconded by Mr. J. E. Bedford, F.G.S., when the party leisurely returned down the valley, enjoying the scenery under the soft and subdued light of evening, to Gargrave, which was reached in good time for the return train. All felt that a pleasant, enjoyable, and instructive day had been spent, and that it would not always be advantageous to be deterred by a cloudy sky.

C. B.

LIST OF OFFICERS.

1891-2.

President: C. BROWNRIDGE, F.G.S.

Vice-Presidents:

J. E. BEDFORD, F.G.S. | W. CHEETHAM.
T. W. BELL. | C. D. HARDCASTLE.

B. HOLGATE, F.G.S.

Hon. Treasurer: W. H. GILL.

Hon. Secretary: W. LOWER CARTER, M.A., F.G.S.

Hon. Assistant Secretaries:

A. E. NICHOLS. E. HAWKESWORTH.

Hon. Librarian: A. E. NICHOLS.

Members of Council:

JOHN INGLEBY. | S. JEFFERSON, F.C.S.
REUBEN NUNNS. | EDGAR R. WAITE, F.L.S.

Publication Committee:

The PRESIDENT, J. E. BEDFORD, C. D. HARDCASTLE, and the HON. SECRETARY.

HONORARY MEMBERS.

Those who have contributed Papers or conducted Excursions are distinguished by an asterisk *

Year of Election.	
1887	*Chadwick, Saml., F.G.S., Mount Pleasant, Malton.
1886	*Cole, Rev. E. Maule, M.A., F.G.S., Wetwang Vicarage, near York.
1889	*Davis, J. W., F.G.S., F.L.S., Chevinedge, Halifax.
1874	*Green, Professor A. H., M.A., F.R.S., &c., Oxford University.
1886	*Horne, Wm., F.G.S., Leyburn.
1891	*Marr, J. E., M.A., F.R.S., Sec. G.S., St. John's College, Cambridge.
1874	*Miall, Professor L. C., F.G.S., F.L.S., &c., 5, Montpellier Terrace, Leeds.
1887	*Sollas, Professor W. J., D.Sc., F.G.S., &c., 4, Clyde Road, Dublin.
1887	*Spencer, Jas., 8, Salisbury Place, Akroydon, Halifax.
1890	*Woodward, W. S., F.G.S., F.Z.S., Natural History Museum, S. Kensington.

LIST OF MEMBERS,

JULY 1891.

1886	Ackroyd, Wm., Wheatleys, Birkenshaw, near Leeds.
1874	*Allbutt, H. A., M.R.C.S., 24, Park Square, Leeds.
1886	Appleby, J. S., 44, 18th Avenue, New Wortley.
1885	Asquith, W. E., 23, Cardigan Road, Leeds.
1888	Baldwin, Chas., G.N.R. Engineer's Office, Queen Street, Leeds.
1890	Baines, Edward, Hunslet, Leeds.

1891 Beaumont, Philip, Gordon Villas, Meanwood.
1888 Bedford, James, Sycamore Lodge, Woodhouse Cliff, Leeds.
1882 *Bedford, J. E., F.G.S., Clifton Villas, Cardigan Road (*Vice-President*).
1874 *Bell, Thos. W., 2, Carr Lane, Leeds (*Vice-President*).
1889 Bingley, Godfrey, Ash Lea, Cardigan Road, Leeds.
1889 Birch, J. Charters, L.D.S., 2, Brunswick Place, Leeds.
1883 Branson, F. W., F.C.S., 14, Commercial Street, Leeds.
1887 Brayshaw, F., 23, Eldon Place, Leeds.
1889 Bricknell, F. W., A.M.I.C.E., Town Hall, Hull.
1887 Briggs, Riley, J.P., Osgodby Hall, near Selby.
1879 Bromley, J. H., Wortley Lodge, Tong Road, Leeds.
1883 *Brownridge, Chas., F.G.S., A.M.I.C.E., Boro. Engineer's Dept., Municipal Buildings, Leeds (*President*).
1889 Burlend, Geo., Newthorpe Lime Quarries, near South Milford.
1887 Carter, Geo. F., Boro. Engineer's Dept., Municipal Buildings, Leeds.
1886 Carter, James, Borough Surveyor's Office, Town Hall, Hull.
1889 *Carter, Wm. Lower, M.A., F.G.S., Meanwood (*Hon. Secretary*).
1875 *Cheetham, Wm., Woodbottom Cottage, Horsforth (*Vice-President*).
1886 Cheetham, W. J., Rawdon Hill, near Arthington.
1890 Clarke, P. T., 60, Wellclose Terrace, Leeds.
1889 Craig, Robert, 49, Springfield Place, Leeds.
1887 Crawley, E. W., Acorn Villas, Ilkley.
1888 Croft, Benjamin, 102, Church Street, Hunslet, Leeds.
1886 Crosland, Richard, 69, Woodhouse Lane, Leeds.
1886 Crowther, J. A., Town Hall, Nelson, Lancashire.
1890 Cuttriss, Saml. W., 6, Fieldhead Terrace, Camp Road, Leeds.
1891 Darnbrough, J. W., 216, Kirkstall Road, Leeds.
1880 Eastwood, Chas., F.G.S., The Gas Works, Linacre, near Liverpool.
1887 Ellis, Edward, A.M.I.C.E., West Lea, Armley.
1889 *Farrar, Abm., Junr., F.G.S., The Grange, Beech Grove, Harrogate.
1887 *Fitton, Wm. H., Highfield House, Beeston Royds.
1890 Foster, Fred, Inland Revenue, Woodlesford.
1889 Gibbins, Henry, 7, Winstanley Terrace, Victoria Road, Leeds.
1876 *Gill, W. H., Park Cottage, Stourton, Leeds (*Hon. Treasurer*).
1879 Gould, Isaac, Hillidge Road, Hunslet.
1880 Gray, T. H., Brookleigh, Calverley.
1889 Gummerson, Chas. J., 7, Winstanley Terrace, Victoria Road, Headingley.
1889 Gurnell, James, 15, Lindon Grove, Dewsbury Road, Leeds.
1889 Hague, Thos. Wm., 28, Nursery Mount Road, Hunslet.
1890 Halstead, Samuel, 67, Burley Lodge Road, Leeds.
1877 *Hardcastle, C. D., 31, Victoria Place, Camp Road, Leeds (*Vice-President*).
1886 *Hawkesworth, Edwin, 60, Bruce Street, New Wortley (*Hon. Assistant Sec.*).
1890 Heaton, Henry, 53, Roundhay Road, Leeds.
1889 Hefford, Geo., Chapel Lane, Headingley.
1889 Henderson, J. J., F.R.G.S., West Lee, Kensington Rd., Douglas, Isle of Man.
1887 Hewson, Thos., M.I.C.E., Borough Engineer, Leeds.
1887 Hewson, George, A.M.I.C.E., Boro. Engineer's Dept., Municipal Buildings.
1889 Hewson, Thos., Junr., The Hollies, Roundhay.
1891 Hick, Edwin, 39, Briggate, Leeds.
1884 Hill, Jabez, Municipal Buildings, Leeds.
1885 Hill, John, Mount Pleasant, Morley.
1891 Hill, George, 5, Oak Terrace, Headingley.
1880 Hives, John, 2, Abyssinia Street, Leeds. *President*).
1875 *Holgate, Benj., F.G.S., Regent House, Grosvenor Road, Headingley (*Vice-*
1890 Holgate, Chas. H., do. do. do.
1889 Howarth, J. H., The Yorkshire Bank, Skipton.
1891 Illingworth, T. W., M.D., C.M., 38, Carr Road, Nelson.
1887 *Ingleby, John, 12, Bainbrigge Road, Headingley (*Member of Council*).
1886 Jameson, M. W., The Town Hall, Hornsey.
1887 *Jefferson, Saml., F.C.S., Kelso Road, Leeds (*Member of Council*).

1879 *Jones, Rev. E., F.G.S., Fairfax Road, Prestwich, Manchester.
1886 Kay, Stanley R., 5, Winstanley Terrace, Headingley.
1886 Keeble, Edwin, 6, Park Square, Leeds.
1889 Lindley, W. E., Bailey Cottage, Skipton.
1889 Matthews, Fredk. J. Arundel, F.G.S., Holly Ridge House, Headingley.
1888 McGuire, Thos., Grosvenor Road, Headingley.
1891 Martin, Ernest B., Borough Engineer's Office, Leeds.
1887 Metcalfe, W. D., Vine Cottage, Oulton.
1887 Micklejohn, Neil, The Gas Works, Longwood, near Huddersfield.
1886 Micklethwaite, J. L., Gledholt, Newton Hill.
1889 Mitchell, Fred, 98, Albion Street, Leeds.
1889 Moore, Rev. H. H., B.A., St. John's Vicarage, Darwen.
1888 Morant, Alfred, Kendall Terrace, Leeds.
1886 Mylne, J. W., Elmwood Mills, Leeds.
1882 Naylor, Benj., The Hawthorns, Winmoor, Seacroft.
1884 Nettleton, Hugh, Borough Engineer, Weston-Super-Mare.
1886 Nichols, A. E., Borough Engineer's Office, Leeds (*Hon. Assistant Sec.*)
1885 Nunns, Reuben, 41, Whitehouse Street, Hunslet.
1887 Oldroyd, Linley, F.S.I., 5, Oxford Place, Leeds.
1887 Oliver, J., Castlefields, Rastrick.
1890 Parry, John, 6, Lascelles Terrace, Roundhay Road, Leeds.
1886 Pheasey, J., 176, Woodhouse Lane, Leeds.
1888 Pickersgill, F. J., 213, Woodhouse Lane, Leeds.
1889 Pickard, Edward Smith, 49, Briggate, Leeds.
1874 *Pocklington, H., F.R.M.S., 41, Virginia Road, Leeds.
1879 *Pollard, H., 19, Britannia Terrace, New Wortley.
1888 Putman, Ernest W., Boro. Engineer's Dept., Municipal Buildings, Leeds.
1885 Redmayne, John, Grove House, Headingley.
1885 Ripon, The Most Hon. The Marquis of, K.G., Studley Royal, near Ripon.
1881 Roebuck, W. D., F.L.S., Sunny Bank Terrace, Leeds.
1887 *Rowley, Walter, M.I.C.E., F.G.S., Alder Hill, Meanwood.
1890 Scott, George, 30, Victoria Place, Camp Road, Leeds.
1887 Shaw, Herbert, Boro. Engineer's Dept., Municipal Buildings, Leeds.
1886 Silcock, E. G., F.G.S., A.M.I.C.E., Boro. Engineer, King's Lynn.
1887 Smith, W. Howard, C.E., Borough Engineer, Carlisle.
1889 Speight, Josh., 24, Chapeltown Road, Leeds.
1887 Stansfeld, John, Woodville, Clarendon Road, Leeds.
1888 Stead, Ezra, 67, Tonbridge Street, Leeds.
1887 Stephenson, John, Brownberries, Horsforth.
1890 Stephenson, W. E., do. do.
1883 Stockdale, Thomas, Spring Lea, Springfield Mount, Leeds.
1886 Summerscales, A. S., A.M.I.C.E., Borough Engineer's Office, Carlisle.
1888 Swithenbank, Josh., Elm Tree House, Hunslet Road, Leeds.
1888 Thornton, Wm., Capel Street, Calverley.
1891 Thrippleton, John, Burley View, Leeds.
1889 Towers, Wm., 73, Brudenell Grove, Leeds.
1885 Wade, Adam, Millshaw, near Leeds.
1889 Waite, Edgar R., F.L.S., Philosophical Hall, Leeds.
1884 Walker, W. B., 4, Cheltenham Street, Armley.
1887 Walker, A. T., The Elms, Weetwood.
1889 Walker, A. E., Boro. Engineer's Dept., Municipal Buildings, Leeds.
1891 Wallis, Wallis A., 90, Caledonian Road, Leeds.
1886 Wilkinson, J. H., Newlay Grove, Horsforth.
1889 Wilkinson, J. J., Burnside, Skipton.
1891 Witts, J. W., Borough Engineer's Office, Leeds.
1885 Wood, George, Waterworks Depôt, Victoria Road, Leeds.
1885 Wood, R. H., 15, Bainbrigge Road, Headingley.
1888 Wood, W. E., 64, Sholebroke Avenue, Leeds.

LEEDS GEOLOGICAL ASSOCIATION.

Abstract of Accounts—Session 1890-91.

Receipts.	£	s.	d.
To Balance in hand, June 1890...	1	4	9
„ Subscriptions	18	0	0
„ Do. Arrears	9	10	0
„ Adamson Memorial (Repayment of Postages)	0	12	0
„ Sale of Transactions	0	3	0
	£29	9	9

Payments.				£	s.	d.
By Postage of Transactions... ...	0	16	4			
„ „ Notices of Meetings and Excursions ...	4	10	6			
„ Postage, Hon. Secretary ...	1	11	7			
„ „ Treasurer	0	3	9			
				7	2	2
„ Subscription to Y.N.U. to Dec., 1890 ...				0	12	6
„ „ „ „ 1891 ...				0	11	6
„ Printing—R. Crosland				14	15	0
„ Rent of Rooms, to June, 1891				1	5	0
„ Caretaker, for services rendered				0	10	0
„ W. F. Coates, collecting and expenses ...				1	5	6
„ Gas for Lantern Exhibitions				0	3	4
„ Balance in hand, June, 1891				3	4	9
				£29	9	9

Examined and found correct,

W. DENISON ROEBUCK, *Auditor.*

16*th June*, 1891.

Leeds Geological Association.

OBJECT.

The object of this Association is to promote the study of Geology by means of field excursions, exhibition of specimens, reading of original papers, and discussions.

MEETINGS.

The MEETINGS are held on the third THURSDAY Evening in each Month, at Eight o'clock, in the OLD CHEMICAL LECTURE ROOM, Mechanics' Institution, Cookridge Street, Leeds.

EXCURSIONS.

EXCURSIONS are frequently made to places of geological interest.

Members have the title and privileges of Associates of the Yorkshire Naturalists' Union (our Association being affiliated with the Union), and are regularly notified of their Excursions.

SUBSCRIPTION.

ORDINARY MEMBERS :—FIVE SHILLINGS per annum, payable in advance on July 1st in each year.

COUNTRY MEMBERS (residing more than twenty miles from Leeds), Two SHILLINGS AND SIXPENCE per annum. Country Members receive the Transactions as published, but are not notified of the Meetings and Excursions of the Association.

Members are requested to forward their Subscriptions annually to the Treasurer, Mr. W. H. Gill, Park Cottage, Stourton, Hunslet, who has entire charge of the financial business of the Association.

Members may introduce their friends (ladies and gentlemen) at the ordinary Meetings and Excursions of the Association.

Members changing their addresses are requested to communicate with the Hon. Secretary, Mr. W. Lower Carter, Meanwood, Leeds, from whom also forms of Nomination for admission to membership may be obtained.